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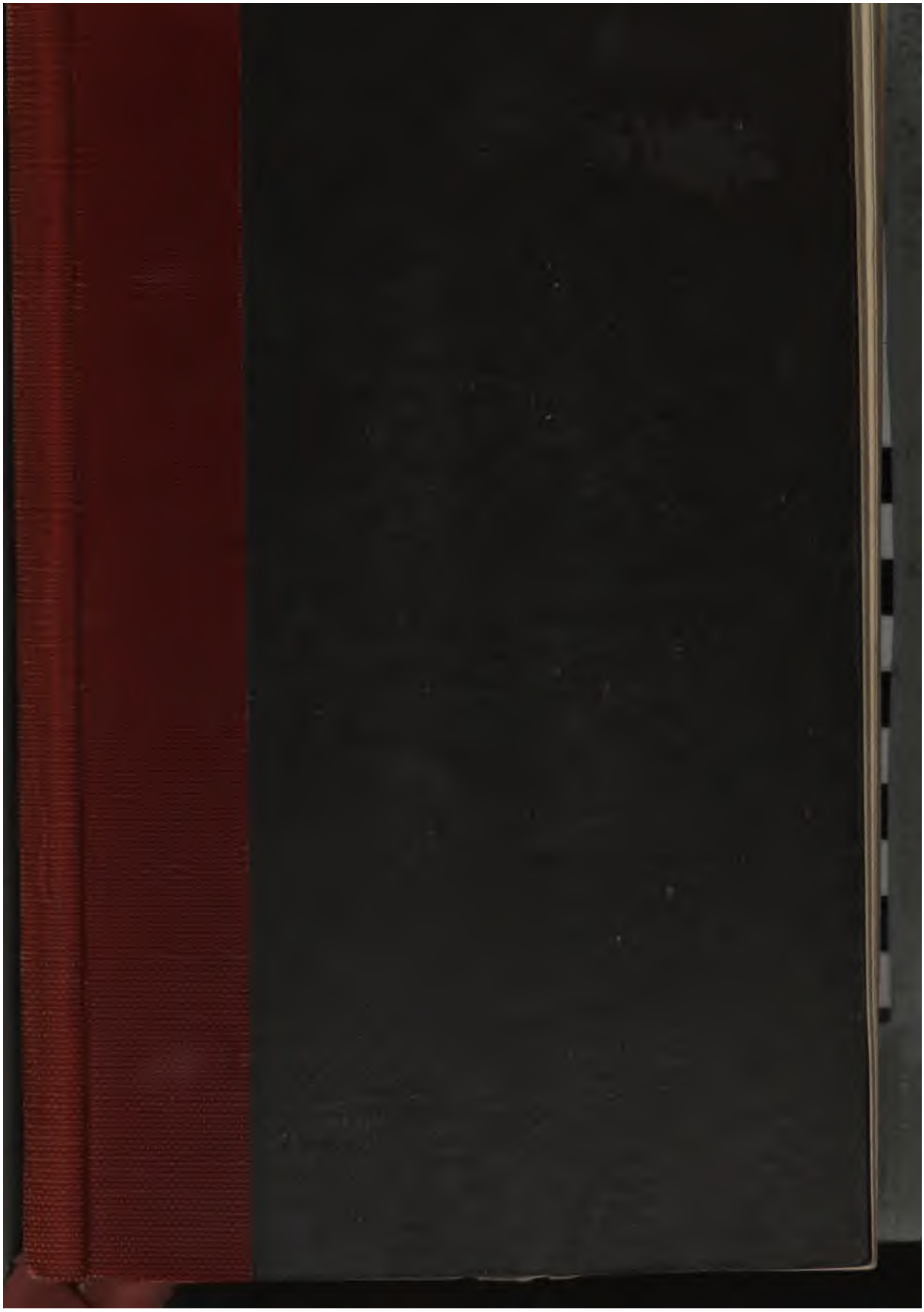

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UNDERFLOW WATERS

OF

SALT RIVER VALLEY, ARIZONA

BY

WILLIS THOMAS LEE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

659134

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
Washington, D. C., June 1, 1904.

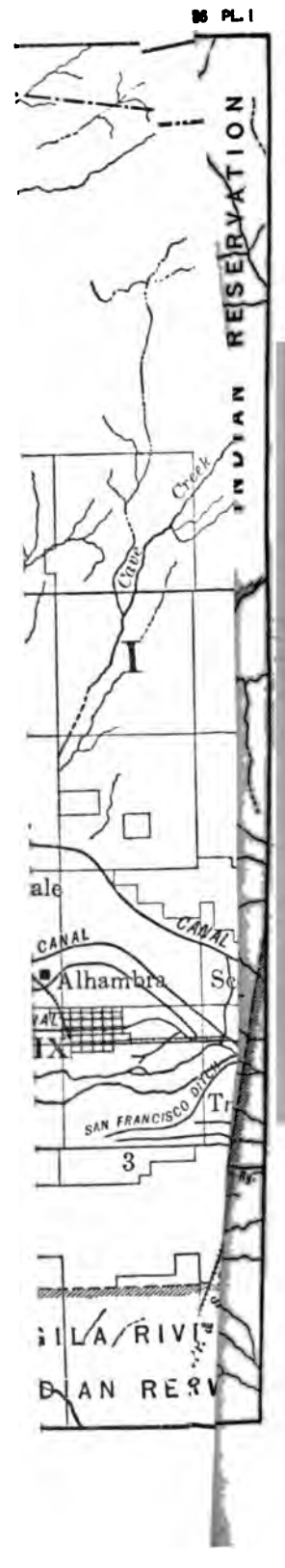
SIR: I forward herewith a report on the underground waters of Salt River Valley, Arizona, by Willis T. Lee, and recommend that it be published as a water-supply and irrigation paper.

Mr. Lee, under the direction of Mr. N. H. Darton, geologist in charge of the western section of hydrology, has made a detailed investigation of the underground waters and geology of Salt River Valley, in the Phoenix region and eastward, and I believe the results will be of value and interest to a large number of persons. The region is one in which the problem of water supply is of great importance, for its prosperity is entirely dependent upon the utilization of the surface and underground waters.

Very respectfully,

F. H. NEWELL,
Chief Engineer.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.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UNDERGROUND WATERS OF SALT RIVER VALLEY, ARIZONA.

By WILLIS T. LEE.

INTRODUCTION.

PURPOSE OF THE INVESTIGATION.

The purpose of this paper is to bring together the facts, so far as known, regarding the underground waters of Salt River Valley, with a view to ascertaining their available quantity, the areas where they occur sufficiently near the surface for economic pumping, and their adaptability for irrigation.

The area of special investigation lies within a line drawn from the junction of Verde and Salt rivers westward a few miles beyond the Agua Fria and southward to Gila River; thence along the northern border of the Pima Indian Reservation to the Superstition Mountains north of Florence, and along the foot of these mountains to the mouth of Verde River—an area, irrespective of the mountains, of about 1,000 square miles. A number of side trips were made beyond this area into the neighboring mountainous districts, but the principal part of the work was done in the lowlands included within the above boundaries. This area is conveniently divided into two districts by a line of buttes that extends across the valley in the vicinity of Tempe, connecting the Phoenix Mountains with the Salt River Mountains. The physical conditions existent east of this line of buttes differ notably from those to the west of it. The division of the valley into two districts is therefore to more purpose than mere convenience of description. The first district, which extends from the mouth of the Verde to Tempe, is known as the Mesa region, and the second, which extends from Tempe to the Agua Fria, is known as the Phoenix region. (See Pl. I.)

CHAPTER I.

WELL RECORDS.

THE MESA REGION.

MURPHY-McQUEEN WELLS (SEC. 34, T. 1 N., R. 5 E.).

The series of deep wells first completed and used for irrigation Salt River Valley is that on the Murphy-McQueen ranch, near the tov of Mesa. This series of we has been described by W.] Code in two publications,[a] a his descriptions are here tra scribed. In the first he writ

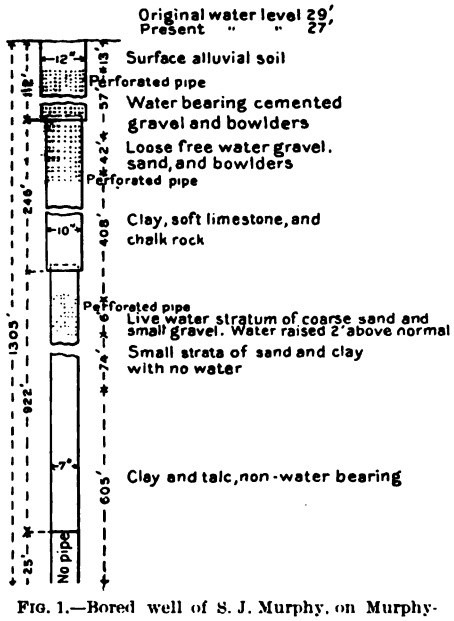


FIG. 1.—Bored well of S. J. Murphy, on Murphy-McQueen ranch, Mesa.

The Murphy well (fig. 1) v started as a 12-inch double-steel-ca one, but on account of the gr difficulties encountered in the w of bowlders and cement strata, gether with a peculiar formation clay known as the swelling varie it has been necessary to reduce t size of the well three times in t depth of 1,305 feet, ending with casing 7 inches in diameter.

In the later and more co plete report Mr. Code writ as follows:

Four 12-inch bored wells w sunk on a line, with 12½-feet cente The first one was put down 1,305 f in the hope that an artesian fl might be obtained. As the drill was still in a nonwater-bearing stratum of cl and talc when this depth was reached it was decided, after having penetrated t stratum 605 feet, to abandon the search for artesian flow and depend upon pum for raising the water. The remaining three wells, therefore, were drilled to a dep of approximately 212 feet, the formations intercepted being as follows:

[a] Code, W. H., Report of irrigation investigations for 1900, No. 2: U. S. Dept. Agric., Bull. 104, 1 p. 93; Report of irrigation investigations for 1901, No. 1: U. S. Dept. Agric., Bull. 119, 1902, pp. 65–6

MURPHY-McQUEEN PUMPING PLANT.

Record of wells bored on Murphy-McQueen ranch.

	Feet.
face alluvial soil	13
mented gravel and bowlders	157
se free water gravel, sand, and bowlders	42
Total	212

Below this depth lay another stratum of clay, soft limestone, and chalk rock, 408 feet in thickness.

The pipes were all perforated thoroughly, and a central shaft was sunk to a depth of about 23 feet, which was very close to the normal water level, and from the bottom of this shaft tunnels were run in either direction in order that small sections of the steel well casings might be removed at this level and the wells all connected to one horizontal suction pipe. The four wells were connected by means of a longitudinal suction pipe, from which were suspended the vertical suction pipes leading down in each well to a depth of 25 feet or more below normal water level. The longitudinal pipe was attached to a 12-inch horizontal centrifugal pump having a capacity of 4,000 gallons per minute and located at the bottom of the shaft. The pump was driven by a steam plant, which, in brief, consisted of the following: One boiler, 5 by 16 feet, estimated capacity 80 horsepower; 1 automatic 12 by 16 inch engine, running condensing; 1 brick cement-lined condensing pit, 10 by 22 feet and with a depth of 5 feet, containing 40 2-inch pipes 20 feet in length.

The steam is condensed in the pipes by the water discharged from the centrifugal pump, which passes through the pit previous to its discharge into the irrigating ditches leading to the alfalfa fields. The machinery is all inclosed by a neat brick house, and the entire plant has a substantial appearance. [Pl. II.]

The writer was employed to superintend a test run of the plant after its completion, and through the courtesy of the owners is privileged to embody the following data from the report made to them.

The test run of the plant was begun at 7 a. m., July 4, 1901, and was completed at 7 p. m., July 11, 1901. The intention was to operate continuously for six days, but, owing to a twelve hours' enforced stop for repairs to the engine on July 8, the time was extended to six and one-half days. The average height to which the water was raised during the test was about 44 feet, the discharge pipe being several feet above the ground level. The machinery was run to its maximum economical capacity, and the results obtained were as follows:

Data obtained by test run of pump on Murphy-McQueen ranch.

Number of hours consumed in test	156
Number of hours consumed in stoppages (breaks, oilings, etc.)	26.4
Total number of hours operated	129.6
Average number of inches pumped (Arizona measure)	270
Average number of inches pumped (California measure)	338
Total number of acre-feet pumped	72.4
Total cords of fuel used	34.75
Daily expense of twenty-four hours' run, aside from fuel:	
Two engineers, at $2.25 per diem	$4.50
Two firemen, at $1.50 per diem	3.00
Oil and waste	.75
Estimated cost of repairs and maintenance	1.00
Total	9.25

Total expense of operation during test:

6½ days, at $9.25 per diem	$6
34¾ cords of wood, at $3 per cord	10
Total	16

Cost per acre-foot of water pumped:

Total cost of pumping	$16
Acre-feet of water pumped	7
Cost per acre-foot	$

Expense for each hour actually running:

Total expense	$16
Number of hours actually run	12
Cost per hour	$
Lift, in feet	
Average cost per foot of raising an acre-foot of water	$0.

The normal level of water previous to the test was 22½ feet below the average face of the ground. The water level in each of the wells at the end of the te shown in fig. 2. The sketch shows that the water in the deep well was not di

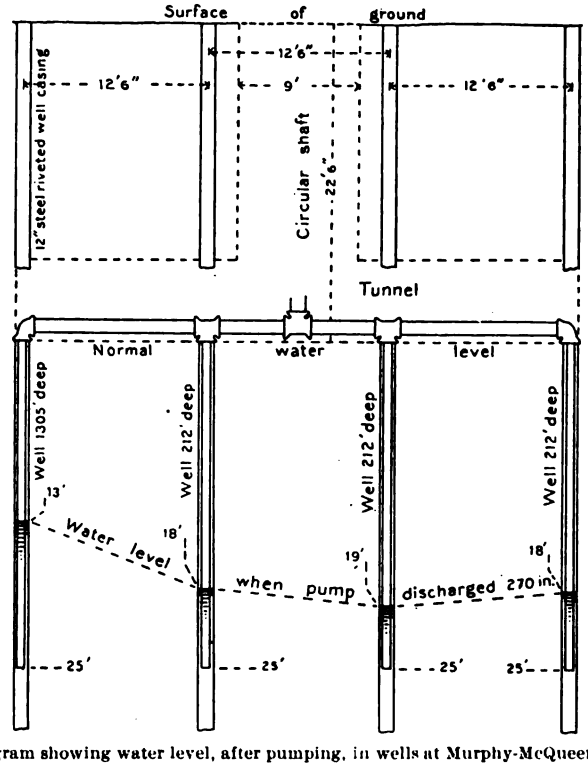


FIG. 2.—Diagram showing water level, after pumping, in wells at Murphy-McQueen plant, n Mesa.

down to within 5 feet or more of the level in the other three wells, which seem indicate that the well driller was right when he affirmed that it would furnish greatest supply of water. He based his opinion upon the fact that at a dep 620 feet, after having penetrated an impervious stratum of clay 408 feet in thick

a 6-foot gravel stratum was encountered which caused the water level in the pipes to rise 2 feet above the normal level.[a]

Two samples of pumped water were sent to Prof. R. H. Forbes, of the University of Arizona, at Tucson, to be analyzed for the purpose of ascertaining its value for irrigation purposes. The first was obtained shortly after the pump was started, and the second near the end of the test run; and it will be noted that the analysis of the latter showed considerable decrease of salts, which would warrant the assumption that continued pumping would effect further improvement. In the opinion of Professor Forbes it would not be wise to depend on well water alone for irrigation purposes, but where it can be used in connection with large quantities of silty river water the danger of depositing an excess of salts on the lands is minimized. The following table gives the results of the analyses made by Professor Forbes:

Analyses of water from Murphy-McQueen wells.

[Laboratory No. 2615, May 17, 1901.]

Quantitative (parts in 100,000):	
Total solids soluble at 110° C	133.20
Chlorine as NaCl (common salt)	82.00
Hardness as $CaSO_4$ (sulphate of lime)	11.15
Nitrogen as nitrates	.426
Nitrogen as nitrites	.0067
Qualitative:	
Sulphates	Very strong.
Magnesia	Very strong.
Lime	Very strong.
Bicarbonates	Pronounced.
Silt	Small amount.

[Laboratory No. 2670, June 27, 1901.]

Quantitative (parts in 100,000):	
Total solids soluble at 110° C	123.20
Chlorine as NaCl (common salt)	74.60
Hardness as $CaSO_4$ (sulphate of lime)	9.79
Nitrogen as nitrates	.263
Nitrogen as nitrites	Trace.
Qualitative:	
Sulphates	Very strong.
Magnesia	Very strong.
Lime	Very strong.
Bicarbonates	Pronounced.
Silt	Slight traces.

Since the first Murphy-McQueen well is the deepest in the valley and penetrates formations that no other well penetrates, it may be in place here to anticipate certain conditions which will be described later and to comment on questions which are of vital importance to those who intend to establish pumping plants in other parts of the valley. First, the principal water-bearing formation is comparatively near the surface, but after penetrating a thickness of 408 feet of impervious material another water-bearing stratum is encountered. This stratum,

[a] The writer measured the depth to water in these wells on January 19, 1904, and found the distance to be 34 feet. In the four years, therefore, since Code's measurements were made the water table at this point has lowered 11.5 feet.

although only 6 feet thick, is not local in occurrence, as is shown by the quantity of water it supplies. As already stated, the water from this stratum rose 2 feet higher than that from the horizon above. The log of the well is given below:

Log of bored well of S. J. Murphy, on Murphy-McQueen ranch, Mesa, Ariz.

	Feet.
Surface soil	13
Cemented gravel and bowlders, water bearing	159
Loose gravel, sand, and bowlders, water bearing	42
Clay, "soft limestone, and chalk rock"	408
Gravel and coarse sand, water bearing	6
Alternating layers of sand and clay	72
Clay and "talc"	605
Total	1,305

Only one other well in the Mesa region has penetrated to the depth of the lower flow. One of the first series of wells on the Chandler ranch is 705 feet deep, but did not encounter this sand. This, however, does not necessarily indicate that the lower stratum may not be

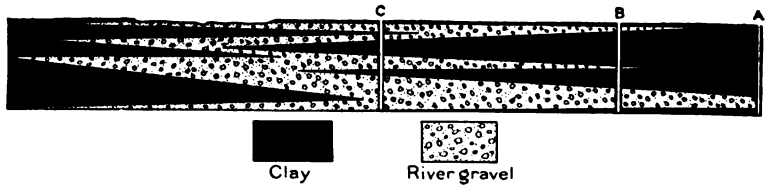


FIG. 3.—Ideal cross section in Salt River Valley, illustrating migrations of river as valley floor was built up.

found in other parts of the valley. Variation and abrupt change in the character of the valley fill, both vertically and horizontally, render it as probable that this stratum increases in thickness and perhaps passes into bowlder beds riverward as that it thins and disappears. Since the river is the main source of the valley fill, and since it is the only source of the extensive bowlder beds in the center of the valley, we naturally expect more or less coarse material from bottom to top of the valley fill. As the river swung back and forth across the valley in the process of depositing the valley fill, we should expect to find the greatest amount of coarse material in the center of the valley, although occasional layers should be found near the outer edges where the river left it during an excursion to the side. However, as explained in another place, the hill wash is always working downward to meet the river wash. The natural result is that at any given horizon bowlders should be found where the river flowed at the time the horizon was the land surface. Back from the river the material should be finer, perhaps sand, and still farther back it should run into clay, silt, cement, or wash, as the case may be.

This change in deposits is illustrated in fig. 3, in which A represents a well some distance from the center of the valley, and B another, more nearly medial. In A bowlders and water are encountered only at a considerable depth (the case with one of the Chandler wells), while at B they are found near the top and again midway. If the well does not go through the second clay we have the case of the Murphy-McQueen well. In this case the same horizon in A yields no water—as was just cited in the 705-foot Chandler well. Wells put down in the center of the valley would probably encounter a greater aggregate thickness of water-bearing gravel, while a well at the extreme left would be entirely outside of the water-bearing sands and gravels and yet be in purely fluviatile material.

An attempt was made to take the temperature of the 1,305-foot well. At a depth of 349 feet the thermometer lodged apparently in sand. The temperature at this depth was found to be 78.1° F. At a depth of 150 feet the temperature is 77.6° F., an increase downward of only 0.5° for 199 feet.

CONSOLIDATED CANAL COMPANY'S WELLS.

The Consolidated Canal Company owns a large central power plant situated at the edge of the mesa north of the town of Mesa. The plant is so constructed that water power may be used when water can be secured in sufficient quantities. Water for the Tempe canal is taken from the river at the upper end of the valley and conducted through the consolidated canal to the surface of the mesa, where it descends through the power plant to the lower level of the Tempe canal. During times of low water the power is created by steam, using crude oil as fuel. According to P. E. Fuller, the engineer in charge, the plant is supplied with two 250-horsepower water-tube boilers, one 400-horsepower compound condensing engine, one 300-kilowatt electric generator, and a complete fuel-oil system, together with necessary auxiliary equipment. The plant supplies electric power to the towns of Mesa and Tempe, but is principally used in pumping water for irrigation. The electric power is transmitted to the pump stations at 11,000 volts, where it is transformed to 220 volts for the 50-horsepower motors. Power is supplied at present to four pumping plants, each yielding about 200 inches of water continuously. The power plant is designed for a maximum of six pumping plants, yielding a total of 1,200 inches of water. About 3,300 acres of land are now supplied with water from the four pumps and this acreage is being rapidly increased. Each pumping plant cost $8,000 complete, while the central power plant cost $50,000.

Mr. Fuller has conducted certain experiments on the cost of pumping water, some of which are quoted in detail later. His general conclusion is as follows:

The water is lifted a total distance of 50 feet and the water-horsepower is 28.33. The actual power consumed at the motor in pumping this water is 42.88, representing a combined efficiency of 66.06 per cent. A number of losses occur from the engine shaft to the motor, and it therefore requires 57.17 horsepower at the engine shaft to pump 200 inches of water, and, as this represents 28.33 water-horsepower, there is a total efficiency for the plant of 49.55 per cent.

Oil costs $1.65 a barrel of 42 gallons. The fuel item I found to be 1 cent per horsepower per hour at the engine shaft, or 57.17 cents per hour for 200 inches of water, or 0.285 cents per inch per hour. Inasmuch as the lifts in the various plants here discussed are different, I have resolved into cost per inch, per foot, and per hour. The above plant costs on this basis 0.0057 of a cent per inch per foot lift per hour.

PLANT NO. 1.

The first pumping plant was established about 6 miles south of Mesa (sec. 22, T. 1 S., R. 5 E.). There are three double-steel-cased 12-inch drilled wells 15 feet apart. They are 705 feet, 236 feet, and 146 feet deep, respectively. At a depth of 80 feet a gravel and bowlder bed 156 feet thick was encountered. The water from this bed is admitted through perforations in the casing and rises to within 36 feet of the surface. Below the bowlder bed occurs a clay containing small bands of sand and gravel and continuing downward at least to a depth of 705 feet, the depth of the well. Following is a log of the well:

Log of the Consolidated Canal Company's well at plant No. 1.

	Feet.
Soil and clay	42
Sand	3
Clay and cement	35
Gravel and bowlders, water bearing	156

Over the central well a shaft 9 feet in diameter is sunk to a depth of 31 feet. From the bottom of this tunnels are run laterally to communicate with the wells on either side. A horizontal suction pipe, from which a vertical suction pipe extends into each well, as described for the Murphy-McQueen plant, connects the wells. An 8-inch horizontal centrifugal pump is placed at the bottom of the shaft in order to be within suction distance of the water, and an electric motor is attached by direct connection. The water is thus drawn from the wells by suction and forced to the surface above through a large delivery pipe. (See Pl. III.)

Several instructive pumping tests were made at this plant in the spring of 1902 for the purpose of ascertaining the capacity of the wells both individually and collectively and the effect upon the general water level.

Pumping tests of the Consolidated Canal Company's plant No. 1.

[March 10, 1902.]

Original depths of wells:	Ft.	in.
North well	705	0
Central well	146	0
South well	236	0

Depth of water below the surface previous to starting the pump:

	Ft.	in.
North well	34	8½
Central well	34	8
South well	34	11

Test No. 1.—Central well alone (others being shut off): After two hours' steady pumping the water stood (below surface):

	Ft.	in.
North well	36	7½
Central well	55	4
South well	36	3

Quantity pumped: 50 inches (563 gallons per minute).[a]

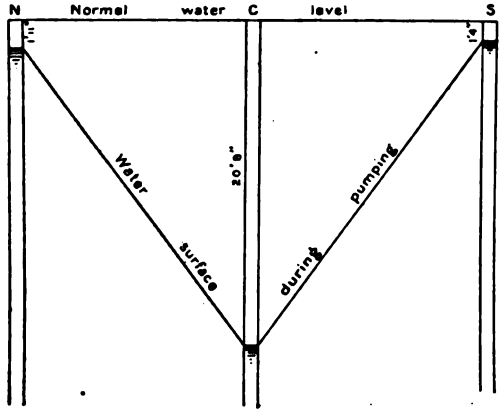


FIG. 4.—Depression of water table during test No. 1.

Test No. 2.—North well (others being shut off): After seven hours' steady pumping the water stood (below surface):

	Ft.	in.
North well	46	6
Central well	38	0
South well	36	8

Quantity pumped: 83 inches (934 gallons per minute).

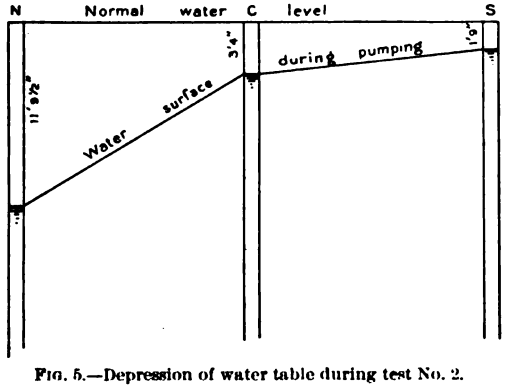


FIG. 5.—Depression of water table during test No. 2.

[a] Measurements of water in this paper are given in "Arizona inches." The measurements are reduced to absolute quantities by reckoning 40 inches as equivalent to the discharge of 1 cubic foot of water per second.

Test No. 3.—South well alone (others being shut off): After two hours' steady pumping the water stood (below surface):

	Ft.	in.
North well	36	5
Central well	36	5
South well	48	5

Quantity pumped: 75 inches (844 gallons per minute).

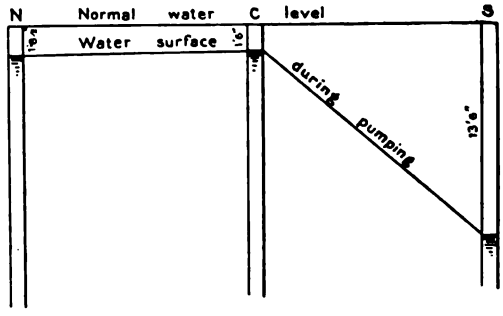


FIG. 6.—Depression of water table during test No. 3.

Test No. 4.—North and south wells coupled (central well shut off): After pumping one hour the water stood (below surface):

	Ft.	in.
North well	42	7
Central well	38	9
South well	43	7

Quantity pumped, 128 inches (1,440 gallons per minute)..

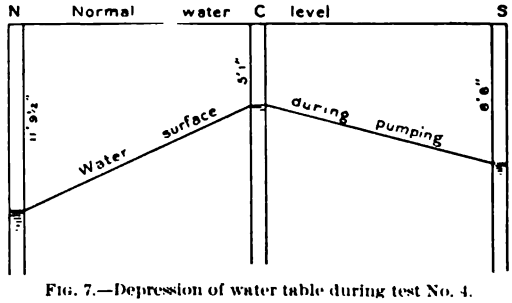


FIG. 7.—Depression of water table during test No. 4.

Test No. 5.—All wells combined: After pumping several hours the water stood (below surface):

	Ft.	in.
North well	41	4
Central well	41	2
South well	40	8

Quantity pumped, 128 inches (1,440 gallons per minute).

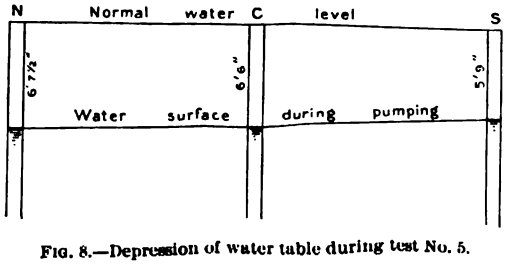


FIG. 8.—Depression of water table during test No. 5.

Analyses of water from wells at Consolidated Canal Company's plant No. 1.[a]

	1. Analysis of water taken from 705-foot well before any extensive pumping had been done.	2. Analysis of water taken from 236-foot well soon after establishment of plant but after thorough pumping.	3. Analysis of water from wells at plant No. 1 after the pump had been in occasional operation for about fifteen months.	4. Analysis of water from wells at Consolidated Canal Co.'s plant No. 1 after long-continued pumping.
Quantitative (parts in 100,000):				
Total soluble solids at 110° C	299.60	163.80	127.40	179.00
Chlorine in terms of NaCl (common salt)	154.80	104.40	75.60	116.80
Hardness in terms of $CaSO_4$ (sulphate of lime)	20.90	44.50	23.10	53.30
Alkalinity in terms of Na_2CO_3 (black alkali)	.00	.00	.00	.00
Nitrogen in the form of nitrates	.29	.12	.07	Trace.
Nitrogen in the form of nitrites	.0105	Very faint.	Trace.	.00
Qualitative:				
Sulphates	Very strong.	Very strong.	Strong.	Very strong.
Magnesia	Strong.	Very strong.	Distinct.	Strong.
Lime	Strong.	Very strong.	Pronounced.	Strong.
Bicarbonates	Strong.	Strong.	Strong.	Slight.

[a] These analyses, as well as the greater number of those to follow, were made by Prof. R. H. Forbes and W. W. Skinner, at the Government experimental laboratory at Tucson, Ariz.

The sample of water represented by analysis No. 2 was taken after the well had been thoroughly cleared by pumping. It may therefore be taken as representative of the true quality of the water pumped at the time the sample was taken. Samples from the other two wells were taken at the same time. That from the 705-foot well yielded 157.40 parts of total soluble solids in 100,000 parts of water, and that from the 146-foot well showed 172.20 parts in 100,000. The analysis of the water from the 236-foot well given above may be taken, therefore, as an average representative of the three wells.

An inspection of these figures brings clearly to mind the fact that the water in a well not in active operation is not a fair representative of the general supply, there being in this case at least a difference of 135.8 parts of soluble salts in 100,000 parts of water. There are many instances in the valley where water for analysis has been taken under similar circumstances and are therefore of questionable value. The inspection also reveals a difference in the proportion of the various salts, which may be due to one or more of several causes, such as the commingling of the waters of different composition, the contact of these waters with new formations, chemical reactions within the steel casing, exposure to the atmosphere, or the relief of pressure. The last two would apply especially to alterations in the bicarbonates, which are abundant in these waters. The relief of pressure and the exposure to the atmosphere would have a tendency to allow the escape of the carbon dioxide necessary to keep the normal carbonates in solution and thus allow the bicarbonates to change to their insoluble form and be

deposited. There should therefore be a smaller showing of lime in standing water than in that drawn from the deeper unexposed sources. In the above samples the proportion is 20.90 to 44.50, the samples being taken from the same well before and after thorough clearing of the well by pumping.

The lime is stated in terms of calcium sulphate. This does not mean that the lime is of necessity combined as a sulphate. Much of the lime reckoned as calcium sulphate probably occurs as calcium bicarbonate. The loss of carbon dioxide (CO_2) from this compound, which occurs when the pressure is relieved, as in the case of transferring the water from the well to the surface, changes it to the comparatively insoluble calcium carbonate ($CaCO_3$), which is deposited as a solid. This phenomenon of deposition of lime when water stands exposed is well illustrated in the annoying deposition of lime in kettles and drinking cups in which water containing carbonates is used.

The third analysis indicates a marked decrease in the amount of soluble salts. There is a popular belief throughout the valley that wells improve by use. In many cases where the judgment is based upon taste it is probable that the quality of the water has changed less than the taste of the persons using it. In the case of the Chandler wells, however, the analyses seemed to indicate that there might be an actual and notable improvement in the water as the wells are used. On the other hand, a change in the opposite direction is indicated by the analyses of the Phoenix city supply, which are given in the description of the Phoenix wells. The improvement of the water by the continued use of the wells is so desirable that too much importance is likely to be attached to any indication of such improvement. This is well illustrated in analysis No. 4, above. After the sample for No. 3 was taken the well was in continuous operation for about nine months, when the sample was taken for analysis No. 4. If continuous pumping will improve the quality of the water the last analysis should show improvement. On the contrary, it indicates a notable increase in the salt contents.

An attempt was made January 19, 1904, to take the temperature of the 705-foot well. It was found, however, that the well had filled with sand to the 375-foot level. The temperature at this depth is 84.6° F., while the temperature at the depth of 150 feet was found to be 81.1° F., making an increase in temperature downward of 1° F. for 64.3 feet.

PLANT NO. 2.

A second pumping plant, similar in construction to No. 1, has been established 1,000 feet east of the former. Two 15-inch double-steel-cased wells have been put down to a depth of a little over 246 feet, and a central shaft 31 feet deep, with a tunnel connecting it with the wells on either side, has been constructed, containing a 10-inch centrifugal pump and electric motor, as described for the first plant.

This plant was completed in June, 1903, and a careful pumping test was made, the results of which are kindly furnished by Dr. A. J. Chandler for this report. The tests were conducted under the direction of Mr. P. E. Fuller.

Log of well at Consolidated Canal Company's plant No. 2.

	Feet.
Soil, clay, and cement	22
Cement	14
Sand, water bearing	10
Cement	6
White clay	30
Sand, gravel, and bowlders	164
Yellow clay	(?)

Pumping test of wells at Consolidated Canal Company's plant No. 2.

[Data furnished by Dr. A. J. Chandler.]

AVERAGE OF READINGS OF BYRON JACKSON 10-INCH HORIZONTAL CENTRIFUGAL PUMP.

[Readings for 30 minutes averaged.]

Speed, r. p. m	852
Vacuum, in feet	15.30
Pressure, in pounds	13.75
Head, in feet, between gages	3.66
Head, in feet, due to vacuum	15.30
Head, in feet, due to pressure	31.68
Total head, in feet	50.65
Depth of water in 36-inch weir	7.75
Miner's inches flowing	197.5
Net water horsepower	28.33

Miner's inch taken at 1½ cubic feet per minute.

AVERAGE OF READINGS OF WESTINGHOUSE TYPE "O" TWO-PHASE MOTORS.

Speed of motor, r. p. m	852
Total amperes in both phases	188
Difference of potential	205
Apparent energy, kilowatts	38.54
Watt meter speed	40
True energy, in kilowatts	32.80
Power factor	83.03
Actual horsepower consumed	42.88
Combined efficiency	66.06
Efficiency for motor	82.50
Efficiency for pump	80

Efficiencies for units are correct. Others based upon pump guaranty.

From the figures thus obtained the cost of raising water is computed:

Computation of cost for pumping plant No. 2 of the Consolidated Canal Company.

Cost of wells and machinery	$8,000.00
Interest on investment at 7 per cent per annum for 2.44 hours	$0.16
Depreciation at 10 per cent per annum for 2.44 hours	$0.23
Time in hours to pump 1 acre-foot of water	2.44

80.03 kilowatts, at 3 cents	$2.40
Oil and incidentals (estimated)	$0.05
Total cost per acre-foot	$2.84
Lift, in feet	50.64
Average cost per foot in lifting 1 acre-foot of water	$0.056

In computing the cost, the cost of the power used could not be ascertained owing to the lack of definite experiments in the development of that power. This item is therefore reckoned at the rate at which it would be furnished by the Electric Light and Fuel Company of Phoenix.

PLANT NO. 3 (SEC. 34, T. 1 S., R. 5 E.).

A third pumping station has been established about 2 miles south of the first. Two double-steel-cased 15-inch wells have been drilled 262 feet deep, and provided with a 10-inch centrifugal pump and an electric motor, as in the wells previously described. The water-bearing gravels lie 42 feet deeper here than in the first set of wells, and the gravel beds are correspondingly thinner. But the water rises to practically the same elevation as in the other wells, 37 feet below the ground surface. Following is a log of the well:

Log of well at Consolidated Canal Company's plant No. 3.

	Feet.
Surface soil	4
Sand	3
Hardpan	5
Sand	4
Clay	8
Sand	12
Clay	8
Cement	6
Sand, water bearing	10
Clay	20
Cement	4
White clay	16
Yellow clay	10
Green clay	12
Gravel and bowlders, water bearing	136
Clay and sand	4

The plant was put in operation in June, 1903, and a pumping test made under the direction of Mr. Fuller.

Pumping test of wells at Consolidated Canal Company's plant No. 3.

[Data furnished by Dr. A. J. Chandler.]

AVERAGE OF READINGS OF BYRON JACKSON 10-INCH HORIZONTAL CENTRIFUGAL PUMP.

[Readings for 30 minutes averaged.]

Speed, r. p. m.	860
Vacuum, in feet	14.30
Pressure, in pounds	12.50

Head, in feet, between gages	3.85
Head, in feet, due to vacuum	14.34
Head, in feet, due to pressure	29.37
Total head, in feet	47.56
Depth in water in 36-inch weir	7.87
Miner's inches flowing	202
Net water horsepower	27.22

Miner's inch taken at 1½ cubic feet per minute.

AVERAGE OF READINGS OF WESTINGHOUSE TYPE "O" TWO-PHASE MOTORS.

Speed of motor, r. p. m	860
Total amperes in both phases	186
Difference of potential	205
Apparent energy, kilowatts	38.13
Watt meter speed	40
True energy, in kilowatts	32
Power factor	83.09
Actual horsepower consumed	42.88
Combined efficiency	63.48
Efficiency for motor	80.80
Efficiency for pump	78.50

Efficiencies for units are correct. Others are based upon pump guaranty.

From the figures obtained in this test the computation of cost is as follows:

Computation of cost of well No. 3 of the Consolidated Canal Company.

Cost of wells and machinery	$8,000.00
Interest on investment at 7 per cent per annum for 2.4 hours	$0.15
Depreciation at 10 per cent per annum for 2.4 hours	$0.19
Time in hours to pump 1 acre-foot	2.4
Kilowatts used to pump 1 acre-foot	76.8
76.8 kilowatts, at 3 cents	$2.30
Oil and incidentals (estimated)	$0.05
Total cost per acre-foot	$2.69
Lift, in feet	47.56
Average cost per foot in lifting 1 acre-foot of water	$0.054

Analyses of water from wells at Consolidated Canal Company's plant No. 3.

	Sample taken before any pumping had been done.	Sample taken after thorough pumping.	Sample taken after the pump had been in continuous operation for about eight months.
Quantitative (parts in 100,000):			
Total solids soluble at 110° C.	162.40	84.80	82.60
Chlorine in terms of NaCl (common salt)	80.40	44.60	41.20
Hardness in terms of $CaSO_4$ (sulphate of lime)	52.20	18.50	1.10
Alkalinity in terms of Na_2CO_3 (black alkali)	.00	.00	.00
Nitrogen in the form of nitrates	.274	.266	.10
Nitrogen in the form of nitrites	.0061	Trace.	.0
Qualitative:			
Sulphates	Very strong.	Strong.	Strong.
Magnesia	Strong.	Distinct.	Distinct.
Lime	Very strong.	Strong.	Distinct.
Bicarbonates	Strong.	Very strong.	Strong.

PLANT NO. 4 (SEC. 34, T. 1 S., R. 5 E.).

A fourth pumping station has been established about a quarter of a mile east of No. 3. There are two double-steel-cased wells about 200 feet deep, equipped with electric motor and pump as described for the other plants belonging to this company. The plant was put in operation about January 1, 1904. No pumping tests have yet been made, but the plant yields apparently the same volume of water as the wells just described.

Analysis of water from wells at Consolidated Canal Company's plant No. 4.

[Sample taken January 28, 1904.]

Quantitative (parts in 100,000):	
Total solids soluble at 110° C.	69.00
Chlorine in terms of NaCl (common salt)	40.00
Hardness in terms of $CaSO_4$ (sulphate of lime)	14.70
Alkalinity in terms of Na_2CO_3 (black alkali)	.00
Nitrogen in the form of nitrates	.20
Qualitative:	
Sulphates	Strong.
Magnesia	Distinct.
Lime	Distinct.
Bicarbonates	Strong.

PLANT NO. 5 (SEC. 15, T. 2 S., R. 5 E.).

A fifth pumping plant was started about 11 miles south of Mesa, where a 15-inch double-steel-cased well was sunk 365 feet. The conditions encountered were unfavorable for a satisfactory pumping plant, and no more wells were put down. At a depth of 58 feet a 4-foot water-bearing sand stratum was encountered from which the water rose 7 feet—that is, to within 51 feet of the surface. No more water was found until the bowlders were encountered at a depth of 365 feet. Water from the bowlder bed rose to the same level as that from the stratum above—that is, to within 51 feet of the surface. No test of the quantity available has been made.

Log of well at Consolidated Canal Company's plant No. 5.

	Feet.
Soil	7
Gravel	5
Yellow clay	12
Sand and gravel	12
White clay	22
Sand, water bearing	6
Packed gravel	22
Cemented sand	24
Clay	8
Cemented sand	6
Clay	4
Gravel	6
Clay	74
Sand	2
Clay	20
Sand	2
Yellow clay	78
Red clay	23
Soft white clay	34
Bowlders	(?)

The material passed through in this well is in marked contrast with that of the neighboring wells. The upper 136 feet has much coarse material, but contains little water. There is thus far little difference in material from the upper 126 feet of the wells at No. 3, about 3 miles to the north. In the wells at No. 3 water-bearing bowlders occur from the 126-foot level down to 262 feet, where clay is encountered. In the wells at No. 5 clay begins at the 134-foot level and extends downward to a depth of 365 feet, where the bowlders are encountered. Here, then, is a case where a bowlder bed 136 feet thick either pinches out entirely, giving place to clay within a distance of about 3 miles, or inclines downward 239 feet in this distance.

PLANT NO. 6.

About 1 mile east of pumping plant No. 1 a dug well 58 feet deep contains water in sufficient quantity to warrant the establishment of a pumping plant. It is said that in digging this well a hard layer of cement was encountered at a depth of a little less than 58 feet. When this was broken through the water at once rose 16 feet in the open well—that is, to within 42 feet of the surface. This well is in slightly higher ground, but the water level is practically the same as that in the wells 1 mile to the west, at pumping plant No. 1. The water beneath the cement layer is probably the same as that encountered in the wells of plant No. 1 at a depth of 36 and 42 feet, respectively, and in the wells 2 miles to the south at 50 feet deep. In the deep wells this water-bearing sand was found to be from 3 to 10 feet thick, and to contain a large amount of water.

The analysis indicates that this water is completely separated from the water in the bowlder bed beneath. Two characteristics are worthy of special notice—the absence of sulphate of lime and the presence of a large amount of black alkali. In these respects the water is in marked contrast with that found only 36 feet below, which has much sulphate of lime and no black alkali.

Analysis of water from well at Consolidated Canal Company's plant No. 6.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C.	103.20
Chlorine in terms of NaCl (common salt)	48.80
Hardness in terms of $CaSO_4$ (sulphate of lime)	.00
Alkalinity in terms of Na_2CO_3 (black alkali)	7.63
Nitrogen in the form of nitrates	.21
Nitrogen in the form of nitrites	.0094
Qualitative:	
Sulphates	Strong.
Magnesia	Distinct.
Lime	Distinct.
Carbonates	Slight.

PLANT NO. 7.

A well has been drilled at the power house of the Consolidated Canal Company, 2 miles northwest of Mesa, for the purpose of obtaining water for use at the engine house. It is a 15-inch double-steel-cased well, and is 68 feet deep. The upper 14 feet is an admixture of sand, silt, and bowlders of the recent river deposit. Below this a cemented bowlder bed occurs and continues unchanged to the bottom of the well. The bowlder bed is probably the same as that represented in the edge of the mesa at that point. The well is but a few feet from the bluff represented in Pl. IV, A.

Log of well at Consolidated Canal Company's plant No. 7.

	Feet.
Sand, silt, and gravel	14
Cemented bowlders	54

A. EDGE OF THE MESA NEAR CONSOLIDATED CANAL COMPANY'S POWER PLANT.

B. A. J. HANSEN'S PUMPING PLANT.

Discharging 5.18 inches of water.

SEEPAGE WELL.

age well was constructed near the power house of the ted Canal Company, under the direction of W. H. Code, escribed it in the report previously referred to.[a] nt is not now in operation. Mr. Code's descrip- gure are here transcribed because of their bear- the quantity of water obtainable from surface ar the river.

r has had some experience in the sinking of open wells r Valley, which may be of value to some horticulturists who contemplate a similar work. To a man who has ual experience with the bowlder and quicksand strata in digging wells in this vicinity, the mere excavation ell may seem ordinarily easy.

olidated Canal Company decided to investigate the under- r supply in the vicinity of their water-power plant near Since it was to be simply an experimental well, it was t to construct it in the least expensive manner possible. nd in view a contract was given to some miners to sink ep as we should desire, at a stipulated price per linear th, we to keep the water out of their way and also to lumber for cribbing the well. The miners proceeded in common in the sinking and timbering of mining shafts, the water out of their way as per contract. The natural the ground water was 7 feet below the surface level at lected, and for this distance the excavation was in earth. epth on the formation was alternate layers of quicksand rs. The well was 8 by 16 feet, inside measurement, and erseverance in the face of many obstacles, we sunk it to 3 feet below the normal level of the water. It is needless detail concerning the trouble and expense connected with kind of a well through the material above mentioned to ficient to give a maximum flow of 4 cubic feet per second s inches). We were taught by this experience how not wells, for although this one is still in fair condition after several years, we know it is not a permanent structure.

well was sunk as deep as we deemed practicable, the some observations as to the effect of the steady pumping c feet per second (150 miner's inches) on the water levels wells. Pits were sunk at varying distances from the large , and careful levels were taken of the surface of the water previous to the test run, the elevations being found prac- ame. The pump was started in the central well and dis- nstant stream of 3.75 cubic feet per second for one hundred urs, near the end of which time levels were again taken of the various sumps. The sketch herewith submitted shows the experiment (fig. 9). It will be seen that the water well pumped from was lowered to a depth of 17.68 feet al level. No. 1, distant 55 feet, to a depth of 6.76 feet below ; No. 2, distant 90 feet, to a depth of 5.94 feet below normal , distant 118 feet, to a depth of 4.90 feet below normal level; No. 4,

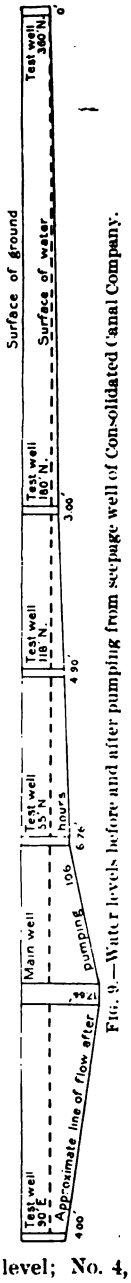


FIG. 9.—Water levels before and after pumping from seepage well of Consolidated Canal Company.

a. Report of irrigation investigation for 1900, No. 2: U. S. Dept. Agric., Bull. 104, fig. 14.

distant 180 feet, to a depth of 3.50 feet below normal level; and No. 5, distant 360 feet, to a depth of 1 foot below normal level.

It will be noted that the sump at a distance of 360 feet from the main well was lowered a depth of about 1 foot and that the steepest cone of depression was that between the main well and the test hole No. 1.

OLSEN WELLS (SEC. 18, T. 1 S., R. 5 E.).

Mr. E. Olsen's pumping plant is situated about 6 miles southwest of Mesa. There are five 12-inch double-steel-cased drilled wells, 212 feet deep, placed 30 feet apart. A central shaft sunk to water level communicates with the wells as in the pumping plants previously described. A 12-inch horizontal centrifugal pump is placed near the bottom of the shaft and operated by steam power from above. When run at ordinary speed the pump is said to discharge 375 inches of water (4,219 gallons) per minute. The wells yield this amount readily, the action of the pump lowering the water only 8 feet below the normal level.

Log of E. Olsen's well.

	Feet.
Sandy soil with bands of cement	46
Clay	2
Coarse gravel and bowlders, water bearing	82
Sand	4
Clay	12
Coarse gravel	14
Sand	10
Sand and gravel	6
Clay	24
Sand	12

The principal water-bearing stratum was encountered at a depth of 48 feet and is 82 feet thick. The water from this stratum rises to a level 19 feet below the surface of the ground. This level, however, varies somewhat at different times. On February 1, 1903, measurements were made to determine the amount of the lowering of the water level caused by the pump. On April 14, 1903, measurements were again made under the same conditions, the quantity of water discharged by the pump being the same in each case, 4,219 gallons per minute. The water level at the time of the first measurement was 2 feet lower than at the time of the second measurement. The normal water level, indicated by the elevation of the water when the pumps were not running, had also risen about 2 feet during this time. This variation of water level seems to be due to an annual change, although observations have not extended over a sufficient length of time for determination.

The analysis of water from Mr. Olsen's wells indicates a large content of salts. The sodium carbonate or black alkali, which is most harmful, is, however, absent. The sulphate of lime is harmless, and

the common salt, although very abundant, could be washed out of the soil with comparative ease should it accumulate in too large quantities. The nitrates, so valuable in irrigation, are abundant. It is possible, as many believe, that the continued use of so saline an irrigation water for a series of years will prove harmful to the land, unless precautions are taken to prevent the accumulation of salts in harmful quantities. The quantity and kind of salt which may be present in irrigation waters depend so largely upon the physical and chemical composition of the land irrigated and upon the manipulation of that land that prediction is useless without a more extended knowledge of facts.

Analysis of water from E. Olsen's well.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C.	381.00
Chlorine in terms of NaCl (common salt)	235.20
Hardness in terms of $CaSO_4$ (sulphate of lime)	59.84
Alkalinity in terms of Na_2CO_3 (black alkali)	.0
Nitrogen in the form of nitrates	2.00
Nitrogen in the form of nitrites	Faint.
Qualitative:	
Sulphates	Very strong.
Magnesia	Strong.
Lime	Very strong.
Bicarbonates	Very strong.

HANSEN WELLS (SEC. 35, T. 1 S., R. 4 E.).

Mr. A. J. Hansen's pumping plant is located about 10 miles south of Tempe. There are four 12-inch drilled wells, double-steel cased, 30 feet apart, and sunk to a depth of 200 feet. A central shaft containing a 12-inch horizontal centrifugal pump is sunk to water level. From this shaft tunnels communicate with the wells as explained for the Murphy-McQueen plant, and the wells are connected by a horizontal suction pipe. The pump is operated at the surface by steam power, connected by belt to the pump.

No satisfactory tests have been made on the capacity of the plant. The best measurements obtainable indicate a yield of about 518 inches (see Pl. IV, *B*), or something over 5,000 gallons of water per minute. Mr. Hansen is preparing to irrigate, in this way, his entire tract of something over 1,100 acres. At the present writing about 500 acres are supplied with pumped water.

When the pump is run at full speed, drawing from the four wells alike, the water level in the wells is lowered 9 feet 3 inches, making the total lift 26 feet 3 inches. When the water is drawn entirely from an end well, the others being shut off, the water level in that well is said to lower 18 feet, while in the well 90 feet distant it lowers 5 feet. The effect on the intervening wells was not determined.

In drilling the wells very little surface water was encountered, but at a depth of 76 feet water-bearing gravels and bowlders were encountered, from which the water rose 53 feet—that is, to 17 feet below the surface of the ground.

Log of A. J. Hansen's wells.

	Feet.
Soil, sand, and cement	72
Hard cement	4
Coarse sand, gravel, and bowlders, water bearing	124

In the course of the drilling two circumstances were noted indicating the looseness of the water-bearing gravels. In drilling the last well it was noted that the water in the first one, 90 feet distant, moved in unison with the plunge of the sand pump. As the sand bucket, with its massive attachments, descended, the water surface in the first well was agitated and moved slightly upward. As the sand bucket was withdrawn the water surface was lowered slightly, maintaining a churning motion in unison with the drill. The second circumstance was noted in connection with sinking the casing. The casing is usually forced downward under heavy pressure by means of hydraulic jacks into the hole made by the sand pump. In Mr. Hansen's wells the gravels were so loose that the casing settled into them of its own weight and had to be held back to prevent it from settling faster than desired.

Three analyses have been made of water from these wells, the first taken January 2, 1903, and the second March 2, 1903, before any extensive pumping had been done. A third analysis was made May 14, 1904, after the pump had been in constant operation for about five months.

Analyses of water from A. J. Hansen's wells.

	No. 1.	No. 2.	No. 3.
Quantitative (parts in 100,000):			
Total solids soluble at 110° C	509.0	446.8	442.0
Chlorine in terms of NaCl (common salt)	355.0	307.0	311.0
Hardness in terms of $CaSO_4$ (sulphate of lime)	60.9	135.4	151.2
Alkalinity in terms of Na_2CO_3 (black alkali)	.0	.0	.0
Nitrogen in the form of nitrates		Faint.	Trace.
Nitrogen in the form of nitrites		Faint.	.01
Qualitative:			
Sulphates	Very strong.	Very strong.	Very strong.
Magnesia	Very strong.	Very strong.	Strong.
Lime	Very strong.	Very strong.	Very strong.

TEMPE CANAL COMPANY'S WELLS (SEC. 19, T. 1 N., R. 4 E.).

The Tempe Canal Company has undertaken the construction of a large pumping plant, designed to augment the water supply of the Tempe canal. A battery of ten 15-inch wells is planned. Two of these are completed at the present writing. The wells are 50 feet apart, and will be operated from a central station. It is expected that the ten will yield 1,000 inches of water. It is the purpose of the company to increase the output to 3,000 inches, if water is found in sufficient quantity to warrant such expansion.

The pumps will be so placed as to discharge the water into the Tempe canal, thus mixing the pumped water with the river water and distributing it uniformly.

The material encountered in these wells differs notably from that in neighboring wells in the absence of the great number of bowlders. The material is described as sand and gravel rather than as gravel and bowlders, as in other wells, and the lower 33 feet is clay.

Log of Tempe Canal Company's wells.

	Feet.
Soil	10
Sand and gravel	157
Clay	33

VALLEY SEEDLESS GRAPE COMPANY'S WELLS (SEC. 4, T. 1 S., R. 4 E.).

The company's vineyard is situated about 4 miles south of Tempe. There are two 12-inch drilled wells, one at the southern end of the vineyard, 348 feet deep, and one at the northern end, 250 feet deep. In the 250-foot well water-bearing gravels were encountered at a depth of about 190 feet. The water from the gravel bed rose to a level 18 feet below the surface of the ground. The 348-foot well is on higher land and the water level is 30 feet below the surface. No careful driller's record was kept, but the foreman in charge reported that the material passed through was a mixture of sand, clay, and cement to a depth of about 120 feet. At this depth sands and gravels begin and alternate with granitic wash to a depth of about 300 feet. No water worthy of mention was found until a bed of gravel 9 feet thick was encountered at a depth of about 275 feet. Below the 300-foot level the material is granitic wash down to 340 feet, where hard red granite was found. The well penetrates the granite 8 feet.

The 250-foot well is not in use at the present time. The 348-foot well is operated to irrigate the vineyard by a centrifugal pump placed in a shaft sunk to near water level and operated by a 12-horsepower gasoline engine. The water is pumped into a small cement reservoir from which it is distributed for irrigation.

Repeated efforts were made to secure measurements in a test run of this plant for the purpose of computing the cost of water thus obtained. In the meantime Prof. S. M. Woodward, of the Arizona Experiment Station, working independently to the same end, obtained measurements which he has kindly allowed me to use. The test run consumed 1.5 hours, the quantity of water pumped during that time being measured in the cement reservoir and the rate per second computed. The water in the well was lowered 11.5 feet when the pump started and remained constant during the run. The water was lifted 5.5 feet above the level of the ground, making a total lift of 47 feet. The plant is still in an experimental stage and certain easily remedied faults in construction will reduce the cost given below. Owing also to these imperfections, the liability to error in measurements is needlessly great. Those taken by Professor Woodward are probably as accurate as can be obtained at the present time. The original cost of the plant could not be obtained and attendance is not included in the following computations:

Cost of pumping water at the Valley Seedless Grape Company's vineyard.

Rate of discharge in cubic feet per seconds	1.15
Distillate consumed per hour, in gallons	1.6
Time to pump 1 acre-foot, in hours	10.52
Distillate consumed per acre-foot of water pumped, in gallons	16.83
16.83 gallons of distillate, at 22 cents	$3.70
Oil and incidentals	$0.05
Total cost per acre-foot	$3.75
Lift in feet	47
Average cost per foot in raising an acre-foot	$0.08

Analyses of water from the Valley Seedless Grape Company's wells.

	348-foot well.	250-foot well.
Quantitative (parts in 100,000):		
Total solids soluble at 110° C.	155.8	115.2
Chlorine in terms of NaCl (common salt)	105.4	78.6
Hardness in terms of $CaSO_4$ (sulphate of lime)	21.8	11.4
Alkalinity in terms of Na_2CO_3 (black alkali)	.0	.0
Qualitative:		
Sulphates	Strong.	Strong.
Magnesia	Pronounced.	Pronounced.
Lime	Strong.	Strong.

TEMPE WATERWORKS WELLS.

The town of Tempe is supplied with water from three 12-inch double-steel-cased wells, 152 feet, 147 feet, and 145 feet deep, respectively. The water-bearing gravels were entered at a depth of 12 feet

A. TEMPE BUTTE, SHOWING RESERVOIR NEAR THE TOP.

B. COLLINS WELL, NEAR PHOENIX.

and the surface of the water at 23 feet. The water is under no pressure and is not capped by an impervious clay, as it is in most places throughout the valley.

The plant is a well-equipped one, with a shaft 20 by 20 feet, sunk 15 feet, and containing a Goulds triplex single-acting pump and 30-horsepower electric motor. The three wells are connected by a horizontal suction pipe, from which a vertical suction pipe extends into each well, inside the casing. The water is forced to a reservoir near the top of Tempe Butte, making a total lift of 249 feet. (Pl. V, *A*.)

It is especially worthy of note that at Tempe the water-bearing gravels extend practically to the surface, the shallow wells reaching the same water body from which the deep wells draw. This is not the case 1 mile south of Tempe at H. L. Chandler's well, where the surface waters are separated from the waters of the great bowlder bed by impervious clay. Analyses of water from the deep wells and from shallow wells near by indicate the same kinds of salts in both the shallow and deep wells, but show varying amounts. The following analyses are from wells only a few blocks apart. The town well is perforated only below 90 feet, and the water analyzed from this well is presumably from that depth. The others are from wells about 30 feet deep.

Log of Tempe waterworks well.

	Feet.
Surface soil	4
Clay and bowlders	6
Clay, sand, and bowlders, cemented	2
Loose sand, gravel, and bowlders, water bearing	117
Igneous rock	23

Analyses of water from wells at Tempe, Ariz.

	City waterworks; 152 feet.	Casa Loma Hotel.	Normal School; 30 feet.
Quantitative (parts in 100,000):			
Total solids soluble at 110° C	103.0	169.8	219.2
Chlorine in terms of NaCl (common salt)	58.8	105.8	133.6
Hardness in terms of $CaSO_4$ (sulphate of lime)	9.52	12.9	15.78
Alkalinity in terms of Na_2CO_3 (black alkali)	.0	.0	.0
Nitrogen in the form of nitrates	.17	.18	.51
Nitrogen in the form of nitrites	.0	.0027	.0
Qualitative:			
Sulphates	Strong.	Very strong.	Very strong.
Magnesia	Strong.	Pronounced.	Very strong.
Lime	Strong.	Very strong.	Very strong.

At the request of the writer, Mr. P. E. Fuller, the engineer under whose direction the pumping plant was constructed, made a careful test of the quantity of water pumped, power consumed, etc. Mr. Fuller has been kind enough to put the observations in the tabular form given below:

Test of pumping plant of Tempe city waterworks, August 2, 1903.

READINGS.

Time.	Voltage between phases.	Total amperes.	Pressure gage.	Vacuum.	Watt meter, one phase.	Revolutions of pump; 6¼ gallons per revolution.	Velocity watt meters per minute.	Difference between gages.
			Pounds.	*Inches.*				
4.20[a] ..	175.0	170	99	15.25	1,747,200	810.310	37.00	3.33
4.40....	177.5	170	99	15.25	1,747,700	811.221	.....	3.33
4.50....	182.5	170	99	15.25	1,748,050	811.623	34.50	3.33
5.....	172.5	170	99	14.75	1,748,320	812.056	34.50	3.33
5.10....	165.0	170	99	14.75	1,748,580	812.487	35.50	3.33
5.20[b] ..	152.5	172	99	14.50	1,748,830	812.848	33.50	3.33
Total.	170.83	170.33	99	14.96	1,630 kw.	2,538 rev.	35.00	3.33

[a] Running start was made; watt meter was 37.3 per cent fast, volt meter was 1 per cent low—for all readings of watts and voltage.
[b] Low readings due to low voltage at power house.

DEDUCTIONS.

Average voltage corrected for error		172.55
Average amperes in both phases		170.33
Apparent energy consumed by motor	kilowatts..	29.39
Actual energy consumed	do...	23.51
Power factor	per cent..	80.00
Horsepower actually consumed by motor		31.51
Average gallons of water pumped per minute		274.95
Total head, in feet, pumped against		248.87
Net water horsepower		18.49
Combined efficiency of motor, pump, suction piping, and ¾-mile 8-inch main	per cent..	58.68
Power rate paid per thousand gallons pumped	cents..	4
Equivalent cost per horsepower per hour and per kilowatt per hour	do...	2.13 2.85

Reducing the figures to the basis of cost per acre-foot of water lifted, we have the following:

Cost of pumping water at the Tempe, Ariz., waterworks.

Cost of plant (not including the reservoir and distributing system)	$3,700.00
Interest on investment at 7 per cent per annum for 19.8 hours.....	$0.59
Depreciation at 10 per cent per annum for 19.8 hours	$0.84
Hours to pump 1 acre-foot	19.8
Cost of power to raise 1 acre-foot (power furnished at 4 cents per 1,000 gallons of water pumped).....	$13.07
Oil and incidentals (estimated).....	$0.05

Total cost per acre-foot	$14.55
Total lift in feet	249
Average cost per foot in lifting 1 acre-foot of water	$0.058

CHANDLER WELL (SEC. 21, T. 1 N., R. 4 E.).

Mr. H. L. Chandler proposes to establish a pumping plant for irrigation about 1 mile south of Tempe. Two 12-inch double-steel-cased wells were started, but accidents have caused a discontinuance of the work. One well, however, reached a depth of 186 feet, and the record, furnished by the driller, is given herewith. The well is in water-bearing gravels and bowlders throughout nearly the entire depth. There seem, however, to be two distinct bodies of bowlders separated by 8 feet of clay. The upper or surface water is alkaline, from which the lower water is probably free, as is the case in other wells of the region. The lower water was struck at a depth of 41 feet below the surface. An unusually large number of heavy bowlders were encountered in these wells, making the drilling a matter of some difficulty, but at the same time indicating a comparatively free passage for the underflow. It is in the beds of coarse gravels and bowlders that the greatest available quantity of water is to be expected.

Log of H. L. Chandler's well.

	Feet.
Soil and cement	11
Gravel and bowlders, water bearing	22
Clay	8
Gravel and bowlders, water bearing	145

A sample of the water was taken for analysis from near the bottom of the well, the water being obtained from the sand pump as the bucket was hoisted. The sample is not therefore representative of the water at this locality. The alkali is probably from water of the upper stratum. Samples of water taken in this way from other wells which were afterwards cleared by pumping show a greater proportion of salts than samples taken after pumping. The analysis, however, is here given for the sake of completeness and for the purpose of indicating something of the quantity of salts contained in the waters of this locality.

Analysis of water from H. L. Chandler's well.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C.	224.00
Chlorine in terms of NaCl (common salt)	146.00
Hardness in terms of $CaSO_4$ (sulphate of lime)	.00
Alkalinity in terms of Na_2CO_3 (black alkali)	2.12
Qualitative:	
Sulphates	Very strong.
Magnesia	Very strong.
Lime	Strong.

This well was utilized to some extent during the summer of 1904. A solar motor, established temporarily, for the past four months has pumped 350 to 380 gallons of water per minute during the hours of sunshine.

FLUMMERFELT WELL (SEC. 11, T. 1 S., R. 4 E.)

Mr. Bristol Flummerfelt has a 6-inch drilled well 61 feet deep. The surface water at his place proved unsatisfactory both in quantity and quality, and his object in drilling was to obtain a supply for domestic use. A solid casing was used to shut off the surface water and the well was put down only 6 feet into the gravels, since all the water needed was obtained at that depth. The quantity and quality of the water from the 55-foot level indicate that it comes from the body encountered as the second horizon in the deeper wells of the same region.

Log of Bristol Flummerfelt's well.

	Feet.
Soil	10
Cement, with sand and gravel	30
Clay	15
Gravel and bowlders, water bearing	6+

Analysis of water from Bristol Flummerfelt's well.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C.	186.00
Chlorine in terms of NaCl (common salt)	122.00
Hardness in terms of $CaSO_4$ (sulphate of lime)	13.60
Alkalinity in terms of Na_2CO_3 (black alkali)	0.00
Qualitative:	
Sulphates	Strong.
Magnesia	Strong.
Lime	Very strong.
Bicarbonates	Very strong.

BARTLETT-HEARD LAND AND CATTLE COMPANY'S WELLS.

D. B. Heard has sunk two wells south of Tempe. The first is 1,000 feet west of the railroad and the second about 2,000 feet east of the railroad. Both are 15-inch double-steel-cased wells, the first 259 feet deep and the second 217 feet. Water was not obtained in satisfactory quantities in either well; the first yielding practically none and the second too little to warrant the establishment of an extensive pumping plant such as was planned. These wells were therefore practically abandoned, and the plant is to be established farther to the west as described elsewhere.

In well No. 1, sunk 1,000 feet west of the railroad (sec. 4, T. 1 S., R. 4 E.), gravels and bowlders were encountered similar to those in other wells of the vicinity, except that they were cemented together

with caliche allowing little water to pass among them. The well is 1,000 feet west of one of the wells at the Valley Seedless Grape Company's vineyard which yields a good supply of water. At this point therefore the line marking the zone of abundant underground water is to be drawn between these wells.

Log of Bartlett-Heard well No. 1.

	Feet.
Soil and cement	34
Gravel	6
Cemented wash	83
Cemented bowlders	136

Well No. 2, sunk 2,000 feet east of the railroad (sec. 3, T. 1 S., R. 4 E.), was found somewhat more promising than the first but the available quantity of water was limited. The material passed through was almost entirely fine wash cemented by caliche; bed rock was struck at a depth of 217 feet. Well No. 2 is farther from the Salt River Mountains by 3,000 feet than well No. 1. It is furthermore in the direction in which, judging from records of other wells, favorable conditions for a satisfactory water supply are naturally expected; yet the well penetrates very little water-bearing material and reaches granite at the bottom.

Log of Bartlett-Heard well No. 2.

	Feet.
Soil and cement	22
Cement, water in pores	14
Cement	30
Bowlders and clay	6
Clay and cement	38
Gravel, water bearing	6
Clay and cement	36
Cement	4
Clay	8
Cement	6
Clay	16
Cement	4
Clay	10
Granitic wash	17
Bed rock	?

JOHNSON WELL (SEC. 30, T. 1 N., R. 5 E.).

Mr. B. F. Johnson has a shallow well 10 by 6 feet and 33 feet deep with 10 feet of water, from which he is pumping about 150 inches of water, using an 8-inch centrifugal pump and a 30-horsepower gasoline engine. The well yields this amount of water readily, the water being lowered by the pump only 3.5 feet.

The available quantity of water seems to warrant more extensive development. Two 12-inch double-steel-cased wells have been drilled and the installation of the pumping plant is in progress. The wells

are 180 feet deep, and penetrate the gravel and bowlders common in that region. It is worthy of note that clay and granitic wash were found beneath the bowlders.

Log of well of B. F. Johnson, near Mesa, Ariz.

	Feet.
Soil	10
Sand, gravel, and bowlders	125
Clay	37
Granitic wash	8

TEMPE-MESA PRODUCE COMPANY'S WELL (SEC. 23, T. 1 N., R. 4 E.).

The company has recently established a pumping plant at its creamery near Tempe. There is one 12-inch double-steel-cased well 100 feet deep. As indicated in the log it is in loose gravel and bowlders through practically the whole depth.

Log of Tempe-Mesa Produce Company's well.

	Feet.
Soil	10
Gravel and bowlders	90

DESERT WELL (SEC. 11, T. 1 S., R. 7 E.).

This well is located about 15 miles southeast of Mesa, on the road leading from Mesa to Florence, and is owned at the present time by Thomas Buchanan. The well, which was dug in 1885, is 212 feet deep and contains 24 feet of water. On a platform near the surface of the water is a pump and small steam engine, supplied by steam generated above ground, which lifts water at the rate of 25 gallons per minute. The surface of the water is lowered 10 feet by the pump, at which stage the inflow equals the demand of the pump.

Log of Desert well.

	Feet.
"Wash" (sand, pebbles, clay, and cement)	150
Sand	2
Cement	20
Sand and gravel	5
Cement	?
Water-bearing gravel	?

The material penetrated in digging the well varies little in the 188 feet exposed above the water. The sides are not cased, except in three places where loose sand was encountered. The material is "wash" from the hills. It is an intimate admixture of clay, sand, and pebbles more or less cemented in places by caliche. The pebbles are angular and give slight indication of the action of water. Although the sides of the well are not protected in any way, they have stood for eighteen years without material change. Little moisture reaches them from the surface, and no water-bearing seams were encountered until near the

bottom. At a depth of 212 feet a cement layer was penetrated and water encountered under sufficient pressure to raise it 24 feet.

Mr. Buchanan reports that the water has been steadily rising in the well for eight years—ever since he has owned the well. Even during the exceptionally dry years of 1901 and 1902, when many of the shallower wells of the valley entirely failed, the water in Desert well steadily increased in volume. This increase is somewhat vividly indicated by the present position of the engine and pump in the well. When placed there the platform upon which they rest was built at a convenient distance above the surface of the water. At the time of my visit the water was 3 feet deep over the platform and the engine and pump were submerged.

The quantity of water does not appear to be such as to warrant the supposition that this well draws from the great gravel beds furnishing the principal flow in the wells farther west. Twenty-five gallons per minute is a small volume compared with that yielded by some of the wells, and yet this yield lowers the water in Desert well about 10 feet. The quality of the water as shown by the following analysis and the elevation of the water 1,260 feet as against 1,134 in the Murphy-McQueen well renders it probable that the stratum from which the desert well draws its supply is connected with what is known as the surface flow of the valley rather than with the deeper and larger flow. In order to strike the level of the water-bearing gravels which supply the water for the large pumping plants of the valley Desert well would have to be lowered about 100 feet.

Analysis of water from Desert well.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C.	32.00
Chlorine in terms of NaCl (common salt)	5.20
Hardness in terms of $CaSO_4$ (sulphate of lime)	.00
Alkalinity in terms of Na_2CO_3 (black alkali)	4.66
Nitrogen in terms of nitrates	.494
Nitrogen in terms of nitrites	Very faint.
Qualitative:	
Sulphates	Faint.
Magnesia	Very faint.
Lime	Faint.
Bicarbonates	None.

KLEINMAN WELL (T. 2 S., R. 9 E.).

Mr. Daniel Kleinman's well is about 10 miles southeast of Desert well and 25 miles southeast of Mesa, on the Mesa-Florence road. It was dug to a depth of 272 feet, and from the bottom a 14-inch pipe was driven 12 feet, making the total depth 284 feet. The log of the well could not be obtained. The quantity of bowlders taken from the well, however, indicates that bowlder and gravel beds make up a large

part of the material passed through. These bowlders have a maximum diameter of something over 1 foot and are thoroughly water worn. They are composed of quartzite and several varieties of granitic rock, together with gneisses and schists, in about the same proportion as they are found in the river bed at the present time.

The water flows from the top of the pipe into the open well, where it stands 2.5 feet deep. It is pumped by horsepower. A team of horses working continuously raises on an average 12.5 gallons per minute.

BOWEN WELL (T. 2 S., R. 9 E.).

Mr. Robert Bowen's well is situated near the south bank of Queen Creek, about 1 mile west of the point where the Florence-Mesa road crosses Queen Creek. The well is dug 212 feet deep and contains 2.5 feet of water. Although the water is so shallow there seems to be no possibility of exhausting it by the means at hand. The well is supplied with both windmill and horsepower for pumping and about 9 gallons per minute may be raised, a yield which does not lower the water level in the well to any appreciable extent. The water is said to show a distinct current flowing toward the west. Floating material gathers at the west side of the well. A float placed at the east side is said to traverse the diameter of the well 4 feet in about three minutes.

The material passed through is nearly all loose gravel and bowlders. The water is not confined by a clay or cement layer, but seems to mark the free surface of the underflow of Queen Creek.

Log of Robert Bowen's well.

	Feet.
Soil	8
Sand, gravel, and bowlders	25
Soft clay	6
Sand, gravel, and bowlders	50
Soft clay	2
Sand, gravel, and bowlders	24
Soft clay	26
Sand, gravel, and bowlders with streaks and bands of clay from a few inches to 2 feet thick	70

Analysis of water from Robert Bowen's well.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C.	54.00
Chlorine in terms of NaCl (common salt)	24.00
Hardness in terms of $CaSO_4$ (sulphate of lime)	16.30
Alkalinity in terms of Na_2CO_3 (black alkali)	.00
Qualitative:	
Sulphates	Distinct.
Magnesia	Distinct.
Lime	Strong.
Bicarbonates	Strong.

HARRINGTON WELL (SEC. 2, T. 2 S., R. 8 E.).

This well, which is owned at the present time by José Granillo, is dug 135 feet deep, and contains about 4 feet of water. No log could be obtained. The well was dug in 1892. The water is raised by horsepower with barrel and rope, and is used for stock and for the traveling public.

ANDRADA WELL (T. 2 S., R. 7 E.).

Sylvester Andrada's well is dug 114 feet deep, and had 14 feet of water when measured. The well, which is used somewhat extensively for watering stock, is provided with a small traction engine and pump. A large cement and cobblestone tank, about 20 feet square and 6 feet deep, serves as a reservoir. The capacity of the pump could not be ascertained, but is not great. When the pump is in operation the water is said to lower about 7 feet, and remains at that level until the pump stops, when the water soon regains its former level. The water is soft, and, judging from taste, contains little salt of any kind.

PRICE WELL (SEC. 11, T. 1 N., R. 4 E.).

Col. J. A. Price has a well 15 feet deep, in which the water was found in the loose gravel and bowlders of the recent river accumulations. Until the plant was burned a few years ago, he pumped it for irrigation continuously at the rate of about 600 gallons per minute, obtaining water at this rate during the dryest times; ordinarily it might have yielded a greater amount.

PARRY WELL (SEC. 14, T. 1 N., R. 4 E.).

Mr. T. J. Parry's well is dug about one-fourth mile south of the river and 1 mile east of Tempe. It is about 40 by 60 feet and 21 feet deep, the water standing 17 feet below the surface of the ground. The level, however, varies with the water in the river; when there are floods in the river the water in the well rises, water marks on the sides of the well indicating that variations of at least 4 feet occur. It is said that the water in the well begins to rise about two days after the crest of the flood has passed.

Water is lifted by means of a 6-horsepower gasoline engine and bucket pump. When run at ordinary speed, the pump discharges 673 gallons per minute. It is operated about six hours a day; a run of four hours in the morning drains the well, but toward evening enough water has accumulated for a two-hour run. The well penetrates only a few feet beneath the water-bearing sands and gravels and is not cribbed or otherwise protected. If sunk a few feet deeper it would undoubtedly yield a much larger and more constant supply.

This plant offered a good opportunity of testing the cost of raising water by means of a bucket pump and gasoline engine. The amount of gasoline was accurately measured and the quantity of water computed from the average number of buckets lifted. (It was found later that owing to a defective valve more gasoline may have been used than was necessary.)

Cost of pumping water at T. J. Parry's pumping plant.

Cost of well (estimated)	$400.00
Cost of engine and pump	$500.00
Interest on investment, at 7 per cent per annum for 8.1 hours	$0.06
Depreciation, at 10 per cent per annum for 8.1 hours	$0.08
Amount of water lifted in 1 hour, in gallons	40,320
Hours required to lift 1 acre-foot	8.1
Gallons of gasoline used in 1 hour	1.2
Gallons of gasoline used in 8.1 hours	9.72
9.72 gallons, at 28 cents	$2.72
Oil, etc. (estimated)	$0.05
Total cost per acre-foot	$2.91
Total lift, in feet	18
Average cost per foot in lifting 1 acre-foot of water	$0.161

JENKINS SEEPAGE DITCH (SEC. 20, T. 1 N., R. 4 E.).

Mr. A. R. Jenkins has a seepage ditch southwest of Tempe. The ditch heads into the area east of Bell Butte, where the underground water surface is at a depth of about 8 feet. It has a maximum depth of 10 feet, thus penetrating the water-charged gravels about 2 feet at the deepest point. Water seeps into the ditch for about one-fourth of a mile, and yields at present about 30 inches. When the ditch was first constructed the underground water stood within 2 feet of the surface, but during the last few years the surface of the underground water throughout this region has been lowering.

The ditch was constructed in 1895 and the land irrigated from it has had little other water since that time. The water is derived from the surface flow south of Tempe and contains the black alkali which is so much feared by the farmers of that region. Mr. Jenkins reports no ill effects to the land from the use of this water, although it has been used almost exclusively for eight years.

Two analyses of water from this ditch show salts as follows:

Analyses of water from A. R. Jenkins's seepage ditch.

	No. 1.	No. 2.
Quantitative (parts in 100,000):		
Total solids soluble at 110° C	189.4	216.4
Chlorine in terms of NaCl (common salt)	136.0	142.9
Hardness in terms of $CaSO_4$ (sulphate of lime)	.0	.0
Alkalinity in terms of Na_2CO_3 (black alkali)	8.4	7.7
Qualitative:		
Sulphate	Very strong.	Strong.
Magnesia	Strong.	Faint.
Lime	Strong.	Strong.

SHALLOW WELLS.

PHIL METS AND ALHAMBRA HOTEL WELLS.

The well at Mets's livery stable may be taken as a fair representative of the shallow wells at Mesa. A careful record of material passed through is given below. It consists of river drift, composed of sand, pebbles, and bowlders, with a subordinate amount of clay and cement. The bowlders are principally composed of quartz, quartzite, and some of the more resistant granitic rocks and have a maximum diameter of 1 foot or more. They are thoroughly waterworn and differ in no essential respect from the materials found at the present time in the bed of the river. The bands of clay and cement contain sand and pebbles in varying proportions.

Log of P. Mets's well, Mesa.

	Feet.
Sandy soil	13
Gravel and bowlders	7
Cement	1
Coarse sand	9
Hard, sandy cement	3
Sand and gravel	19
Hard cement containing sand and small pebbles	4
Gravel, water bearing	2

Water was first struck in the gravels at a depth of 39 feet. This failed in dry times and the well was lowered, obtaining a better supply a little deeper. This supply diminished in time and the well was again lowered. The process of lowering the well continued until at a depth of 52 feet a hard, impervious cement layer 4 feet thick was encountered. The bar with which this was being dug struck through into a bed of loose gravel containing water under slight pressure. The water quickly rose 6 feet. Since that time there has been no shortage, the

water standing steadily 6 feet deep. A yield of 700 gallons per hour, even in the driest times, has little effect on the amount of water in the well.

The water from the 56-foot level is of somewhat different quality from that of higher levels. The water from the Mets well tastes salty, but is otherwise a more palatable drinking water than that of many of the shallower wells of the vicinity.

An analysis of this water is given below, and also one of water from the well at the Alhambra Hotel, in the adjoining block. The Alhambra supply comes from a horizon a few feet above that of the Mets well, probably above the cement stratum at the bottom of the Mets well. Judged by the taste alone the two waters are very different, but the analyses show them very much alike.

Analysis of water from P. Mets's well and the Alhambra Hotel well, at Mesa.

	Mets.	Alhambra.
Quantitative (parts in 100,000):		
Total solids soluble at 110° C	167.80	152.00
Chlorine in terms of NaCl (common salt)	108.00	89.60
Hardness in terms of $CaSO_4$ (sulphate of lime)	.00	.00
Alkalinity in terms of Na_2CO_3 (black alkali)	9.33	5.51
Nitrogen in the form of nitrates	.385	.33
Nitrogen in the form of nitrites	Very faint.	Very faint.
Qualitative:		
Sulphate	Strong.	Strong.
Magnesia	Faint.	Faint.
Lime	Strong.	Strong.
Bicarbonates	Very strong.	Very strong.

VARIATION IN QUALITY.

The water of the various shallow wells in and about Mesa varies in quality to a marked extent. They are all strongly charged with various soluble salts. A study of the analyses shows that common salt, the carbonates, and the sulphates are the most common and are present in large amount in nearly all the waters, but the variation in the proportions of these salts causes the many varieties of water which arouse so much wonder and speculation in the minds of the owners of the wells. In most of the well waters common salt predominates. Nearly all the well water is said to be hard, and lye is very generally used to "break" it; only a few wells contain water which is said to be soft, though the analyses just given show an absence of any permanent hardness. It is possible that the abundance of other salts in the water renders difficult the detection of hardness by the taste.

Many of the wells are so strong in alkali and the bitter salts that they have been abandoned. In other cases the owners have accustomed themselves to the use of water which a stranger could not safely use. In still other cases the water seems to have gradually improved as the well was used. The published analyses do not indicate the range of variation in chemical character, for the reason that only wells yielding waters sufficiently good to be used are preserved. Many wells have been destroyed which yielded water too alkaline or too bitter for use. In other cases wells yielding bitter or intensely alkaline waters are said to have been greatly improved by pumping. In some cases this reported improvement is no doubt due to the education of the taste rather than to the change in character of the water, but in other cases there seem to be good reasons for believing that wells have entered small pockets containing saline solutions and more or less separated from the main body of underground waters. An exhaustion of the limited supply of such saline solutions would allow the entrance of water from the main water body and would effect a corresponding change in character.

TABULATION OF WELLS.

It seemed advisable in the study of the underground waters of the valley to test the existence of a definite regular water table and to determine the relations of such water table to the land surface and to the river, the principal source of the underground supply. Mesa Township (see Pl. XVIII) was selected for this test on account of favorable location and the existence there of a large number of wells. In the townships bordering Mesa the wells are fewer in number, but with the definite information obtainable from the great number of wells in Mesa Township the water table of the Mesa district is satisfactorily determined and is described in Chapter III.

Tabulation of shallow wells.

MESA TOWNSHIP (T. 1 N., R. 5 E.).

[Records obtained by Robert Muldrow.]

Number.	Owner.	Post-office.	Location.			Completed.	How put down.	Depth of well.	Depth to water.	Does water vary at different times of year?	Is water easily lowered?	Did water rise when struck?	Has the volume of water increased or diminished?	Elevation of surface.	Elevation of water.	Remarks.
			Township.	Range.	Section.											
								Feet.	*Feet.*					*Feet.*	*Feet.*	
347	E. E. Jones	Lehi	1 N.	5 E.	1	1887	Dug	41	40	Yes	Yes	No	Diminished	1,241	1,201	Constantly lowered.
346	Ed. Prothero	do	1 N.	5 E.	1	1890	do	43	42	Yes	Yes	No	do	1,242	1,200	Do.
344		do	1 N.	5 E.	1		do	50	49	Yes		No	do	1,250	1,201	Do.
237	George Rogers	do	1 N.	5 E.	2	1889	do	27	26	Yes	Yes	No	do	1,232	1,206	Do.
238	Charles Davis	do	1 N.	5 E.	2	1884	do	33	30	Yes	No	No	do	1,230	1,200	
239	S. B. Steele	do	1 N.	5 E.	2	1890	do	35	32	Yes	No	No	do	1,230	1,200	
240	J. W. Clark	do	1 N.	5 E.	2	1892	do	35	34	Yes	Yes	No	do	1,233	1,199	Do.
241	C. H. Rollins	do	1 N.	5 E.	2	1902	do	35	34		No	No	Neither	1,234	1,200	
342	Joseph Hawkins	do	1 N.	5 E.	2	1901	do	38	37		No	No	Diminished	1,235	1,198	
343					2		do	33						1,236		Dry.
345	B. Noble	Lehi	1 N.	E.	2	1887	do	38	37	Yes	No	No	Diminished	1,234	1,193	Constantly lowered.
348	George Tiffany	do	1 N.	E.	2	1900	do	40		Yes	Yes	No	do	1,238		Dry.
349	S. C. Sorenson	do	1 N.	E.	2		do	40	39	Yes	Yes	No	do	1,237	1,198	Constantly lowered.
353	Wm. Nelson	do	1 N.	E.	2	1898	do	32	31	Yes	No	No	do	1,228	1,197	Do.
354	Ruth Gibson	do	1 N.	5 E.	2		do	31		Yes	No	No	do	1,228		Dry.
356	E. D. Biggs	do	1 N.	5 E.	2	1894	do	33	32	Yes	No	No	do	1,228	1,196	Constantly lowered.
357	Leuella Davis	do	1 N.	5 E.	2	1901	do	30		Yes	No	No	do	1,232		Dry.
361	Thomas E. Jones	do	1 N.	5 E.	2	1902	do	39	37	No	No	No	Neither	1,226	1,199	
363	L. F. Kiggins	Mesa	1 N.	5 E.	3		do	28		Yes	No	No	Diminished	1,221		Do.
362	Harvey Harper	Lehi	1 N.	5 E.	3	1895	do	28	27	Yes	Yes	Yes	do	1,225	1,198	Constantly lowered.
360	D. R. Jones	do	1 N.	5 E.	3	1892	do	30	29	Yes	No	No	do	1,222	1,193	Do.
358	C. G. Shill	do	1 N.	5 E.	3	1902	do	30	29	Yes	Yes	No	do	1,229	1,200	Do.

306	F. J. Davis	....do...	1 N.	5 E.	3	1897	....do...	33	31	No....	Yes...	Yes...	.....do.....	1,211	.....	Dry.
352	O. A. Wing	....do...	1 N.	5 E.	3	1897	....do...	8	.....	Yes...	.....	.....	.....do.....	1,220	1,193	
302	.....	Mesa ...	1 N.	5 E.	4	.....	....do...	27	26	Yes...	Yes...	No....	.....do.....	1,206	.....	Do.
299	Wm. Schwartz	Lehi....	1 N.	5 E.	4	1900	....do...	26	.....	.....	.....	.....	.....	1,213	.....	Do.
123	Charles Bowers	Mesa ...	1 N.	5 E.	4	.....	....do...	20	.....	Yes...	Yes...	No....	Diminished ..	1,212	1,187	
301	E. E. Weller	....do...	1 N.	5 E.	4	1901	....do...	27	25	Yes...	.....	No....	.....do.....	1,210	1,182	
364	Indian	....do...	1 N.	5 E.	5	.....	....do...	21	18	.....	.....	.....	.....	1,215	1,189	
365	.....do.....	.....	1 N.	5 E.	5	.....	....do...	27	26	.....	.....	.....	.....	1,216	1,191	
382	.....do.....	.....	1 N.	5 E.	5	.....	....do...	26	25	.....	.....	.....	.....	1,208	1,184	
385	.....do.....	.....	1 N.	5 E.	6	.....	....do...	25	24	Yes...	No....	.....	Diminished ..	1,210	1,186	
379	.....do.....	.....	1 N.	5 E.	6	.....	....do...	25	24	Yes...	No....	No....	.....do.....	1,206	1,186	
376	.....do.....	.....	1 N.	5 E.	6	.....	....do...	21	20	Yes...	.....	.....	.....do.....	1,210	1,189	
377	.....do.....	.....	1 N.	5 E.	6	.....	....do...	22	21	Yes...	No....	No....	.....do.....	1,207	.....	Dry.
378	.....do.....	.....	1 N.	5 E.	6	.....	....do...	21	.....	.....	.....	.....	.....	1,192	1,176	
369	.....do.....	.....	1 N.	5 E.	7	.....	....do...	18	16	.....	.....	.....	Diminished ..	1,201	1,192	
380	.....do.....	.....	1 N.	5 E.	8	1886	Driven .	15	9	Yes...	Yes...	No....	.....do.....	1,202	1,193	
387	J. B. Wallace	Tempe .	1 N.	5 E.	8	1892	....do...	15	9	Yes...	Yes...	No....	.....do.....	1,203	1,185	
388	Wm. Wallace	....do...	1 N.	5 E.	8	1895	Dug	22	18	Yes...	No....	.....	.....do.....	1,215	1,191	Constantly lowered.
303	E. B. Kearley	Mesa ...	1 N.	5 E.	9	1898	....do...	30	24	Yes...	Yes...	Yes...	.....do.....	1,210	1,190	Do.
300	Frank Sanders	Lehi....	1 N.	5 E.	9	1898	....do...	23	20	Yes...	No....	No....	.....do.....	.....	.....	
304	J. A. Williams	Mesa ...	1 N.	5 E.	9	.....	Driven .	.....	.....	.....	.....	.....	.....	1,232	1,197	
305	David Wallace	....do...	1 N.	5 E.	11	1902	Dug	36	35	Yes...	No....	No....	Diminished ..	1,235	1,196	
351	H. Simpkins	Lehi....	1 N.	5 E.	11	1902	....do...	40	39	No....	No....	No....	Neither.....	1,230	.....	Dry.
350	Hannah Williams	....do...	1 N.	5 E.	11	1895	....do...	23	.....	Yes...	Yes...	.....	Diminished ..	1,226	.....	Do.
333	P. W. Byers	....do...	1 N.	5 E.	11	.....	....do...	25	.....	.....	.....	.....	.....do.....	1,230	1,206	Constantly lowered.
334	.....	.....	1 N.	5 E.	11	.....	....do...	25	24	Yes...	Yes...	.....	.....do.....	1,230	.....	Dry.
335	.....	.....	1 N.	5 E.	11	1901	....do...	20	.....	Yes...	No....	No....	.....do.....	1,244	.....	Do.
336	C. W. Simpkins	Lehi....	1 N.	5 E.	12	.....	....do...	32	.....	.....	.....	.....	.....do.....	1,263	1,197	
372	.....	.....	1 N.	5 E.	12	.....	....do...	67	66	Yes...	No....	No....	.....do.....	1,263	.....	Do.
373	.....	.....	1 N.	5 E.	12	.....	....do...	64	.....	.....	.....	.....	.....do.....	1,282	.....	Do.
374	.....	.....	1 N.	5 E.	12	.....	....do...	64	.....	.....	.....	.....	.....do.....	1,244	.....	Do.
375	.....	.....	1 N.	5 E.	13	1900	....do...	51	.....	Yes...	Yes...	Yes...	.....do.....	1,244	1,181	Constantly lowered.
122	O. C. Bullock	Mesa ...	1 N.	5 E.	14	1892	....do...	54	53	Yes...	No....	No....	.....do.....	1,249	1,184	Do.
314	David Wallace	....do...	1 N.	5 E.	14	.....	....do...	57	55	Yes...	No....	No....	.....do.....			
315	Thos. Jensen	....do...	1 N.	5 E.												

Tabulation of shallow wells—Continued.

MESA TOWNSHIP (T. 1 N., R. 5 E.)—Continued.

Number.	Owner.	Location. Post-office.	Township.	Range.	Section.	Completed.	How put down.	Depth of well.	Depth to water.	Does water vary at different times of year?	Is water easily lowered?	Did water rise when struck?	Has the volume of water increased or diminished?	Elevation of surface.	Elevation of water.	Remarks.
								Feet.	*Feet.*					*Feet.*	*Feet.*	
371	A. J. Chandler	Mesa	1 N.	5 E.	14		Dug	26						1,249		Dry.
117	M. A. Crouse	do	1 N.	5 E.	14		do	55	54	No	No	No	Diminished	1,242	1,187	Constantly lowered.
120	D. Drorbaugh	do	1 N.	5 E.	14		do	50	48	Yes	Yes		do	1,243	1,195	Do.
232	J. M. Schule	do	1 N.	5 E.	15	1887	do	57	56	Yes	No	No	do	1,245	1,189	Do.
119	F. P. Drew	do	1 N.	5 E.	15		do	55	52				do	1,242	1,190	
311	Ed Lewis	do	1 N.	5 E.	16		do	61	60	Yes	Yes	No	do	1,246	1,186	Do.
312	M. F. Davis	do	1 N.	5 E.	16	1900	do	62	60	Yes	No	No	do	1,242		Dry.
313			1 N.	5 E.	16	1897	do	52						1,242		Do.
279	O. S. Stapley	Mesa	1 N.	5 E.	16	1900	do	55	54	Yes	Yes	No	Diminished	1,242	1,188	Constantly lowered.
281			1 N.	5 E.	16		do	52						1,240		Dry.
282	L. D. Crook	Tempe	1 N.	5 E.	16	1900	do	57	55	Yes	No	No	Diminished	1,235	1,180	Constantly lowered.
256	J. P. Leebrick	Mesa	1 N.	5 E.	16	1900	do	61	60	Yes	No	Yes	do	1,246	1,186	Do.
278	I. D. Shumway	do	1 N.	5 E.	16	1897	do	56		Yes	No		do	1,248		Dry.
306	Henry Baker	do	1 N.	5 E.	16		do	56	55	Yes	No	No	do	1,238	1,183	Constantly lowered, very salty.
307	J. T. Lisonbee	do	1 N.	5 E.	16		do	54		Yes	Yes	No	do	1,240		Dry.
308			1 N.	5 E.	16	1897	do	58	56	Yes	No	Yes	do	1,240	1,184	Constantly lowered.
309			1 N.	5 E.	16		do	58	57	Yes	No	No	do	1,243	1,186	Constantly lowered; very salty.
310	J. C. Kimsey	Mesa	1 N.	5 E.	16	1900	do	60	58	Yes	Yes	No	do	1,244	1,186	Constantly lowered; salty.
287	James Nelson	Tempe	1 N.	5 E.	17	1894	do	50	48	Yes	Yes		do	1,230	1,182	Constantly lowered.
386	Wolf Sachs	do	1 N.	5 E.	17	1898	do	19					do	1,195		Dry.
389	J. D. Spooner	do	1 N.	5 E.	18	1898	Driven	18	10	No	Yes	No	Neither	1,188	1,178	
293	E. C. Woodmansee	do	1 N.	5 E.	18	1900	Dug	18	12			Yes	Diminished	1,188	1,176	

294	School	....do...	N	5 E.	18	1901	....do...	19	17	Yes...	No....	No....	Neither.....	1,188	1,172		
295	Wm. Rohrig	....do...	N	5 E.	18	1893	....do...	17	16	Yes...	No....	No....	.....do	1,188	1,175		
296	.....do.....	....do...	N.	5 E.	18	1901	....do...	19	13	.....	No....	Yes...	Diminished...	1,242	1,189		
118	J. M. Boundtree	Mesa ...	N	5 E.	18	1902	....do...	54	53	Yes...	Yes...	Yes...	.....do	1,284	1,235		
82	W. A. Trent	....do...	N	5 E.	19	.....	....do...	50	49	Yes...	Yes...	.....	.....do	1,215	1,178	Constantly lowered.	
268	Z. Martin	....do...	N	5 E.	19	1888	....do...	39	37	.....	Yes...	Yes...	.....do	1,215	1,184		
269	.....do.....	....do...	N	5 E.	19	1899	....do...	31	.....	Yes...	.....	.....	.....	1,213	.....		
270	.....	.....	N.	5 E.	19	.....	....do...	.....	.....	.....	.....	.....	.....	.....	.....		
271	— Gibson	Phoenix	N	5 E.	19	1886	....do...	37	35	Yes...	.....	.....	Diminished...	1,211	1,176	Do.	
272	J. Johnson	Mesa ...	N	5 E.	19	1900	....do...	34	33	Yes...	.....	.....	.....do	1,207	1,174	Do.	
273	R. N. Westover	....do...	N	5 E.	19	1887	....do...	27	26	Yes...	.....	.....	.....do	1,207	1,181		
275	G. N. Finch	Tempe..	N	5 E.	19	1894	....do...	28	26	Yes...	Yes...	No....	.....do	1,193	1,167	Do.	
288	Fanny Dobbie	Mesa ...	N	5 E.	19	.....	....do...	39	37	Yes...	Yes...	.....	.....do	1,215	1,178		
289	.....do.....	....do...	N	5 E.	19	1901	....do...	37	.....	Yes...	Yes...	No....	.....do	1,215	.....	Dry.	
290	L. A. Tewksbury	Tempe..	N	5 E.	19	1901	....do...	38	37	Yes...	Yes...	Yes...	.....do	1,215	1,178	Constantly lowered.	
292	J. W. Stewart	....do...	N.	5 E.		1887	....do...	38	37	Yes...	Yes...	.....	.....do	1,211	1,174	Do.	
235	Loy Schank	....do...	N	5 E.	9	1901	....do...	25	24	Yes...	No....	No....	.....do	1,196	1,172		
236	.....do.....	....do...	N	5 E.	19	1901	....do...	26	25	Yes...	No....	No....	.....do	1,198	1,173		
237	N. W. Brimhall	....do...	N	5 E	19	.....	....do...	27	26	Yes...	Yes...	Yes...	.....do	1,200	1,174		
238	Nora Brimhall	....do...	N	5 E.	19	1899	....do...	30	28	Yes...	Yes...	Yes...	.....do	1,202	1,174		
213	S. A. Stewart	....do...	N	5 E.	20	1894	....do...	44	43	Yes...	No....	No....	.....do	1,224	1,181		
214	J. S. Toney	Phoenix	N	E.	20	1892	....do...	43	42	Yes...	.....	Yes...	.....do	1,222	1,180		
215	.....	.....	N.	E.	20	1887	....do...	37	.....	Yes...	Yes...	Yes...	.....do	1,220	.....	Dry.	
217	J. V. Spainhower	Mesa ...	1 N.	5 E.	20	1896	....do...	40	38	Yes...	Yes...	.....	.....do	1,216	1,178		
259	.....	.....	1 N.	5 E.	20	.....	....do...	50	48	Yes...	No....	.....	.....do	1,228	1,180	Constantly lowered.	
261	W. H. Pew	Mesa ...	1 N.	5 E.	20	1892	....do...	43	.....	Yes...	No....	Yes...	.....do	1,226	.....	Dry.	
262	D. P. Pew	....do...	1 N.	5 E.	20	1897	....do...	46	45	Yes...	No....	Yes...	.....do	1,225	1,180		
263	M. S. Longmore	....do...	1 N.	5 E.	20	1902	....do...	46	45	Yes...	No....	Yes...	Neither.....	1,224	1,179	Constantly lowered.	
264	.....	.....	1 N.	5 E.	20	.....	....do...	43	41	Yes...	.....	Yes...	Diminished ..	1,219	1,178	Do.	
265	A. W. Crismon	Mesa ...	1 N.	5 E.	20	1897	....do...	41	40	Yes...	No....	Yes...	.....do	1,218	1,178	Do.	
266	Ellen Crismon	....do...	1 N.	5 E.	20	1899	....do...	39	.....	.....	.....	.....	.....do	1,218	.....	Dry.	
267	C. T. Wise	....do...	1 N.	5 E.	20	1892	....do...	42	40	Yes...	No....	Yes...	.....do	1,216	1,176	Constantly lowered.	
283	Loretti E. Everton	....do...	1 N.	5 E.	20	1891	....do...	50	.....	Yes...	No....	Yes...	.....do	1,233	.....	Dry.	
285	Otis Rogers	.....	1 N.	5 E.	20	.....	....do...	52	50	Yes...	.....	.....	.....do	1,233	1,183	Constantly lowered.	

Tabulation of shallow wells—Continued.

MESA TOWNSHIP (T. 1 N., R. 5 E.)—Continued.

Number.	Owner.	Post-office.	Location.			Completed.	How put down.	Depth of well.	Depth to water.	Does water vary at different times of year?	Is water easily lowered?	Did water rise when struck?	Has the volume of water increased or diminished?	Elevation of surface.	Elevation of water.	Remarks.
			Township.	Range.	Section.											
								Feet.	*Feet.*					*Feet.*	*Feet.*	
286	H. N. Pew	Mesa	1 N.	5 E.	20	1896	Dug	41	.....	Yes	No	Yes	Diminished	1,231	.....	Dry.
291	M. L. Gray	Tempe	1 N.	5 E.	20	1890	do	39	37	Yes	No	No	do	1,215	1,178	Constantly lowered.
250	Mrs. Lofgreen	Mesa	1 N.	5 E.	21	1902	do	52	50	Yes	Yes	.....	do	1,239	1,189	Do.
251	J. Pierce	do	1 N.	5 E.	21	.....	do	55	54	Yes	Yes	.....	do	1,237	1,186	Do.
252	Julia Dykes	do	1 N.	5 E.	21	1896	do	52	51	Yes	No	.....	do	1,237	1,186	Do.
253	A. Hunsacker	do	1 N.	5 E.	21	1897	do	54	53	Yes	Yes	.....	do	1,235	1,182	Do.
254	do	do	1 N.	5 E.	21	1897	do	55	54	Yes	Yes	.....	do	1,234	1,180	Do.
255	do	do	1 N.	5 E.	21	1899	do	54	53	Yes	Yes	Yes	do	1,233	1,180	Do.
256	W. N. Standage	do	1 N.	5 E.	21	.....	do	58	56	Yes	.....	.....	do	1,234	1,178	Do.
257	Charles Pew	do	1 N.	5 E.	21	1898	do	50	48	Yes	Yes	Yes	do	1,230	1,182	Do.
258	J. A. Stewart	do	1 N.	5 E.	21	1890	do	52	.....	Yes	Yes	Yes	do	1,230	1,178	
260	Alma School	do	1 N.	5 E.	21	1898	do	47	46	Yes	.....	Yes	do	1,227	1,181	Do.
276	H. Stewart	do	1 N.	5 E.	21	1901	do	55	52	.....	No	Yes	do	1,239	1,187	
277	Jessie Pierce	do	1 N.	5 E.	21	1892	do	53	52	Yes	.....	.....	do	1,240	1,188	Do.
278	J. W. Bond	do	1 N.	5 E.	21	1901	do	56	.....	Yes	Yes	No	do	1,244	.....	Dry.
280	M. F. Davis	do	1 N.	5 E.	21	1895	do	55	53	Yes	No	Yes	do	1,240	1,187	Constantly lowered; salty.
284	J. E. Johnson	do	1 N.	5 E.	21	1894	do	56	55	Yes	.....	Yes	do	1,234	1,179	
186	D. A. Johnson	do	1 N.	5 E.	21	1901	do	55	54	Yes	Yes	Yes	do	1,231	1,177	
187	M. A. Crouse	do	1 N.	5 E.	21	.....	do	53	.....	.....	Yes	Yes	do	1,231	.....	Dry.
188	J. S. Coffin	do	1 N.	5 E.	21	1898	do	54	52	Yes	No	Yes	do	1,230	1,178	
205	M. L. Horrell	do	1 N.	5 E.	21	1899	do	44	43	Yes	No	Yes	do	1,225	1,182	
207	J. R. Standage	do	1 N.	5 E.	21	1897	do	47	46	Yes	Yes	.....	do	1,222	1,181	
246	Wm. Crismon	do	1 N.	5 E.	21	.....	do	50	49	Yes	Yes	Yes	do	1,235	1,186	Constantly lowered

248	A. L. Cuber	do	1 N.	5 E.	21	1882	do	53	.....	Yes	Yes	No	do	1,237	.....	Dry.
249	do	do	1 N.	5 E.	21	1889	do	53	51	Yes	Yes	No	do	1,237	1,186	Constantly lowered.
66	E. N. Grard	do	1 N.	5 E.	22	1897	do	40	39	.....	.....	.....	do	1,238	1,194	
65	H. Dana	do	1 N.	5 E.	22	1901	do	49	47	.....	.....	.....	do	1,233	1,186	
181	P. M. Coleman	do	1 N.	5 E.	22	1892	do	45	43	Yes	No	Yes	do	1,232	1,189	
184	George Woy	do	1 N.	5 E.	22	.....	do	37	.....	Yes	Yes	.....	do	1,232	.....	Dry.
244	D. Le Baron	do	1 N.	5 E.	22	1901	do	49	48	Yes	Yes	Yes	do	1,234	1,186	Constantly lowered.
245	M. Forrester	do	1 N.	5 E.	22	1901	do	50	49	Yes	Yes	Yes	do	1,235	1,186	Do.
247	H. B. Morris	do	1 N.	5 E.	22	1884	do	55	54	Yes	Yes	No	do	1,236	1,182	Do.
104	O. S. Stapley	do	1 N.	5 E.	22	1902	do	50	47	Yes	Yes	.....	do	1,238	1,191	
105	Chas. Sellers	do	1 N.	5 E.	22	1902	do	52	50	Yes	No	Yes	do	1,234	1,184	
107	Mesa Milling Co	do	1 N.	5 E.	22	1899	do	52	48	.....	Yes	Yes	do	1,238	1,190	
108	.....	.....	1 N.	5 E.	22	.....	do	42	.....	.....	.....	.....	.....	1,239	.....	
396	Geo. M. Fryer	Mesa	1 N.	5 E.	22	1898	do	50	46	Yes	No	No	Neither	1,237	1,191	
397	H. H. Gillispie	do	1 N.	5 E.	22	1897	do	52	45	Yes	No	No	do	1,237	1,192	
399	L. V. Guthrie	do	1 N.	5 E.	22	1898	do	44	38	Yes	Yes	No	Diminished	1,233	1,195	
400	P. A. Williams	do	1 N.	5 E.	22	1898	do	47	43	Yes	Yes	.....	do	1,233	1,190	
401	Phillip Coleman	do	1 N.	5 E.	22	1902	do	46	40	Yes	No	No	do	1,233	1,193	
403	Phil Mets	do	1 N.	5 E.	22	1901	do	56	48	.....	No	Yes	do	1,239	1,191	
404	John Nelson	do	1 N.	5 E.	22	1902	do	55	49	.....	Yes	Yes	.....	1,243	1,194	
316	Joe Meyers	do	1 N.	5 E.	22	1893	do	49	48	Yes	Yes	No	Diminished	1,235	1,187	Do.
317	S. L. Elder	do	1 N.	5 E.	22	.....	do	49	48	Yes	Yes	No	do	1,236	1,188	Do.
318	School	do	1 N.	5 E.	22	.....	do	50	49	Yes	Yes	No	do	1,236	1,187	Do.
319	M. B. Ullman	.....	1 N.	5 E.	22	.....	do	50	49	Yes	Yes	No	do	1,237	1,188	Constantly lowered; salty.
230	E. W. Jones	Mesa	1 N.	5 E.	22	1896	do	52	51	Yes	No	No	do	1,237	1,186	Constantly lowered.
321	Kimball Pomeroy	do	1 N.	5 E.	22	1894	do	52	51	Yes	Yes	No	do	1,237	1,186	Do.
322	J. H. Pomeroy	do	1 N.	5 E.	22	1882	do	52	51	Yes	Yes	No	do	1,238	1,186	Do.
323	Jack Frazier	do	1 N.	5 E.	22	1890	do	52	51	Yes	Yes	No	do	1,239	1,188	Do.
324	H. L. Chandler	do	1 N.	5 E.	22	1882	do	52	49	Yes	.....	No	do	1,240	1,191	Do.
325	J. Sirrine	do	1 N.	5 E.	22	.....	do	52	51	Yes	No	No	do	1,240	1,189	Do.
326	Chas. Starr	do	1 N.	5 E.	22	1890	do	53	52	Yes	No	No	do	1,240	1,182	Do.
327	School	do	1 N.	5 E.	22	1890	do	54	52	Yes	No	No	do	1,241	1,189	Do.
328	J. Sirrine	do	1 N.	5 E.	22	.....	do	49	48	Yes	No	No	do	1,241	1,193	Do.
329	G. W. Woy	do	1 N.	5 E.	22	.....	do	56	54	Yes	Yes	No	do	1,242	1,188	Do.

Tabulation of shallow wells—Continued.

MESA TOWNSHIP (T. 1 N., R. 5 E.)—Continued.

Number.	Owner.	Post-office.	Location.			Completed.	How put down.	Depth of well.	Depth to water.	Does water vary at different times of year?	Is water easily lowered?	Did water rise when struck?	Has the volume of water increased or diminished?	Elevation of surface.	Elevation of water.	Remarks.
			Township.	Range.	Section.											
								Feet.	*Feet.*					*Feet.*	*Feet.*	
330	City	Mesa	1 N.	5 E.	22	1901	Dug	59	53	.....	No	No	Diminished	1,240	1,187	
331	Geo. Schornick	do	1 N.	5 E.	22	1901	do	56	53	Yes	No	.....	do	1,239	1,186	
176	P. B. Hughes	do	1 N.	5 E.	22	.....	do	47	46	Yes	No	.....	do	1,233	1,187	
177	L. V. Guthrie	do	1 N.	5 E.	22	1896	do	48	46	No	Yes	.....	do	1,233	1,187	
53	N. Fuller	do	1 N.	5 E.	23	1895	do	43	.....	.....	.....	.....	do	1,233	.....	
50	L. Allen	do	1 N.	5 E.	23	.....	do	42	41	.....	.....	.....	do	1,232	1,190	
89	C. W. Fellows	do	1 N.	5 E.	23	1887	do	45	.....	Yes	Yes	.....	do	1,238	.....	Dry.
90	M. K. McArthur	do	1 N.	5 E.	23	.....	do	40	38	Yes	Yes	No	do	1,236	1,195	
91	W. B. Telford	do	1 N.	5 E.	23	.....	do	50	.....	.....	.....	.....	do	1,235	.....	Dry, salty.
92	do	do	1 N.	5 E.	23	.....	do	31	.....	.....	Yes	.....	do	1,235	.....	Dry, soft.
93	Sarah Whitehead	do	1 N.	5 E.	23	1892	do	50	47	Yes	Yes	Yes	do	1,237	1,190	
94	Hiram Phelps	do	1 N.	5 E.	23	1897	do	46	.....	Yes	Yes	Yes	do	1,237	.....	Dry.
95	H. J. Horne	do	1 N.	5 E.	23	1892	do	45	44	Yes	Yes	Yes	do	1,236	1,192	
96	Hiram Phelps	do	1 N.	5 E.	23	1896	do	50	48	Yes	Yes	Yes	do	1,236	1,188	
97	do	do	1 N.	5 E.	23	1888	do	48	.....	Yes	No	No	do	1,236	.....	Do.
98	M. C. Phelps	do	1 N.	5 E.	23	1892	do	49	47	Yes	No	No	do	1,236	1,189	
99	J. M. Horne	do	1 N.	5 E.	23	1892	do	43	40	Yes	Yes	No	do	1,233	1,193	
100	do	do	1 N.	5 E.	23	1901	do	45	44	Yes	Yes	No	do	1,233	1,189	
101	J. R. Morse	do	1 N.	5 E.	23	1887	do	48	47	Yes	No	No	do	1,238	1,192	
102	J. E. Sirrine	do	1 N.	5 E.	23	1892	do	48	47	Yes	Yes	Yes	do	1,238	1,191	
103	Hannah Johnson	do	1 N.	5 E.	23	1898	do	50	48	Yes	Yes	Yes	do	1,238	1,190	
106	Tempe-Mesa Produce Co.	Tempe	1 N.	5 E.	23	1902	do	49	48	.....	.....	Yes	do	1,238	1,190	
109	.....	.....	1 N.	5 E.	23	.....	do	47	.....	.....	.....	.....	.....	1,239	.....	

111	George Woy	Mesa	1 N.	5 E.	23										
112			1 N.	5 E.	23		Dug								
113			1 N.	5 E.	23		do								
114			1 N.	5 E.	23		do								
115	Oscar Whitlow	Mesa	1 N.	5 E.	23		do								
116	Anna Hall	do	1 N.	5 E.	23		do								
119	Oscar Whitlow	do	1 N.	5 E.	23		do								
121	O. Daley	do	1 N.	5 E.	23	1900	do								
83	C. R. Hakes	do	1 N.	5 E.	24	1902	do								
84	W. B. Telford	do	1 N.	5 E.	24	1899	do								
85	L. E. Lamb	do	1 N.	5 E.	24	1900	do								
86	W. B. Telford	do	1 N.	5 E.	24	1896	do								
87	W. L. Sirrine	do	1 N.	5 E.	24	1896	do								
88	E. W. Wilbur	do	1 N.	5 E.	24	1896	do								
35	Mary Peterson	do	1 N.	5 E.	24	1893	do								
39	H. L. Peterson	do	1 N.	5 E.	24	1898	do								
41	C. Peterson	do	1 N.	5 E.	24	1884	do								
30	J. A. Allison	do	1 N.	5 E.	25	1896	do								
31	do	do	1 N.	5 E.	25	1899	do								
32	H. H. Taylor	do	1 N.	5 E.	25	1900	do								
34	P. Weisner	do	1 N.	5 E.	25	1897	do								
37	D. S. Lewis	do	1 N.	5 E.	25	1895	do								
38	do	do	1 N.	5 E.	25	1890	do								
40	H. M. Lewis	do	1 N.	5 E.	25	1897	do								
42	G. W. Lewis	do	1 N.	5 E.	25	1897	do								
46	L. Lewis	do	1 N.	5 E.	25	1897	do								
10	N. H. Price	do	1 N.	5 E.	26	1887	do								
44	C. H. Allen	do	1 N.	5 E.	26	1892	do								
45	W. J. Clark	do	1 N.	5 E.	26		do								
48	J. L. Coleman	do	1 N.	5 E.	26	1900	do								
49	J. S. Allen	do	1 N.	5 E.	26	1896	do								
51	W. Allen	do	1 N.	5 E.	26	1898	do								
52	J. Allen	do	1 N.	5 E.	26	1898	do								
54	W. Brundage	do	1 N.	5 E.	26	1898	do								
45													1,243		
38													1,241		Do.
55	53	Yes	Yes				Diminished						1,241	1,188	
60													1,241		
50	47	Yes	No				Diminished						1,240	1,198	
60	58	Yes	Yes				do						1,239	1,181	
31							Yes	do					1,240		Do.
51	50	Yes	Yes				Yes	do					1,244	1,194	Constantly lowered.
52	51	Yes	Yes				No	do					1,246	1,195	
55	54	Yes	Yes				Yes	do					1,244	1,190	Water has lowered 34 feet since 1899.
50	49	Yes	Yes				No	do					1,243	1,194	
50	49	Yes	Yes				Yes	do					1,242	1,193	
48													1,242		Dry.
50	48	No	Yes				Yes	Diminished					1,238	1,190	Constantly lowered.
60	58	No	Yes					do					1,238	1,180	
50	47	Yes						do					1,236	1,189	
52	49	Yes											1,235	1,186	
45	44	Yes	No					Diminished					1,235	1,195	
52	50	Yes	No					do					1,247	1,195	
50													1,241		
52	50	Yes						Diminished					1,239	1,189	
52	49	Yes	Yes					do					1,236	1,187	
52								do					1,233		
52	50	Yes						do					1,235	1,185	
52	50	Yes						do					1,234	1,184	
38	37							do					1,226	1,189	
44	43	Yes	Yes										1,233	1,189	
39	37	Yes						Diminished					1,228	1,189	
39	38	Yes						do					1,228	1,190	
37	36							do					1,225	1,189	
42													1,232		
50													1,231		
50													1,231		
43	41	Yes						Diminished					1,233	1,192	

Tabulation of shallow wells—Continued.

MESA TOWNSHIP (T. 1 N., R. 5 E.)—Continued.

Number.	Owner.	Post-office.	Location.			Completed.	How put down.	Depth of well.	Depth to water.	Does water vary at different times of year?	Is water easily lowered?	Did water rise when struck?	Has the volume of water increased or diminished?	Elevation of surface.	Elevation of water.	Remarks.
			Township.	Range.	Section.											
								Feet.	*Feet.*					*Feet.*	*Feet.*	
55	N. A. Brundage	Mesa	1 N.	5 E.	26	1898	Dug	42	39				Diminished			
68	S. T. Barnett	do	1 N.	5 E.	26	1896	do	40						1,228		
69	E. Ellsworth	do	1 N.	5 E.	26		do	39	38					1,225	1,187	
72	C. Fuller	do	1 N.	5 E.	26	1900	do	37	35				Diminished	1,220	1,185	
179	M. B. Ullman	do	1 N.	5 E.	27		do	44		Yes	Yes		do	1,232		Dry.
180	Frank Dana	do	1 N.	5 E.	27	1898	do	47	45	Yes	Yes		do	1,232	1,187	Do.
182	Frank Dana	do	1 N.	5 E.	27		do	48		Yes	Yes		do	1,232		
183	A. W. Babbitt	do	1 N.	5 E.	27		do	47	46	Yes	Yes		do	1,232	1,186	
209	H. M. Cooper	do	1 N.	5 E.	27		do	37		Yes	Yes	Yes	do	1,222		Do.
211	do	do	1 N.	5 E.	27		do	41	40				do	1,225	1,185	
212	Joseph D. Crose	do	1 N.	5 E.	27	1899	do	44	42	Yes	Yes	Yes	do	1,228	1,187	
11	H. F. Simmons	do	1 N.	5 E.	27	1900	do	47	44	No	No	Yes	Neither	1,233	1,186	
12	Diffenderfert Ruse	do	1 N.	5 E.	27	1902	do	35	33	Yes	Yes	No	Diminished	1,220	1,187	
13	T. G. Marksbury	do	1 N.	5 E.	27	1886	do	40	38	Yes	Yes	No	do	1,215	1,175	
14	Francisco Arrows	do	1 N.	5 E.	27		do	35						1,219		
15	F. J. Kelley	do	1 N.	5 E.	27	1894	do	34	32	Yes	Yes	No	Diminished	1,217	1,183	
62	F. Marksbury	do	1 N.	5 E.	27	1886	do	41	39				do	1,224	1,185	
63	H. Coleman	do	1 N.	5 E.	27	1893	do	40	39				do	1,224	1,185	
64	J. Drane	do	1 N.	5 E.	27	1893	do	50	48				do	1,233	1,185	
67	A. Millet	do	1 N.	5 E.	27	1891	do	38	37				do	1,228	1,191	
70	R. Longmoor	do	1 N.	5 E.	27		do	40	39				do	1,225	1,186	
75	H. V. Parker	do	1 N	5 E.	27	1900	do	50	49				do	1,220	1,177	
73	L. M. Vance	do	1 N.	5 E.	28	1899	do	33						1,217		
74	J. T. Vance	do	1 N.	5 E.	28	1882	do	36	35				Diminished	1,219	1,184	

140	D. W. Grivel	....do ...	1 N.	5 E.	28	1890	....do ...	32	31	Yes...	Yes...	Yes...	.....do	1,211	1,180	
189	D. D. Smith	....do ...	1 N.	5 E.	28	1901	....do ...	31	.....	.....	.....	.....	.....do	1,230	.....	Do.
190	B. L. Bradford	.....	1 N.	5 E.	28	.....	....do ...	42	41	Yes...	Yes...	Yes...	.....do	1,223	1,182	
191	P. D. Smith	Mesa ...	1 N.	5 E.	28	1900	....do ...	37	.....	Yes...	Yes...	Yes...	.....do	1,223	.....	Do.
192	Henry Baker	....do ...	1 N.	5 E.	28	1891	....do ...	39	38	Yes...	Yes...	Yes...	.....do	1,222	1,182	
193	J. T Vance	....do ...	1 N.	5 E.	28	1892	....do ...	32	.....	Yes...	Yes...	Yes...	.....do	1,215	.....	Do.
195	Merritt Clark	....do ...	1 N.	5 E.	28	1890	....do ...	35	34	Yes...	Yes...	.....	.....do	1,215	1,181	
199	J. F. Bradberry	....do ...	1 N.	5 E.	28	.....	....do ...	37	36	Yes...	Yes...	.....	.....do	1,217	1,181	
203	George Patterson	....do ...	1 N.	5 E.	28	1898	....do ...	41	40	Yes...	Yes...	Yes...	.....do	1,221	1,181	
206	Church	....do ...	1 N.	5 E.	28	1899	....do ...	45	44	Yes...	Yes...	.....	.....do	1,226	1,182	
208	James H. Brooks	....do ...	1 N.	5 E.	28	1896	....do ...	39	38	Yes...	Yes...	.....	.....do	1,220	1,182	
185	I. L. Spain	....do ...	1 N.	5 E.	28	.....	....do ...	46	45	Yes...	No....	.....	.....do	1,230	1,185	
194	E. Cartwright	.....	1 N.	5 E.	29	.....	....do ...	35	33	Yes...	Yes...	.....	.....do	1,214	1,181	
196	C. M. Huffman	Mesa ...	1 N.	5 E.	29	.....	...do ...	31	.....	Yes...	Yes...	.....	.....do	1,215	.....	Do.
197	.....do	....do ...	1 N.	5 E.	29	.....	....do ...	34	33	Yes...	Yes...	.....	.....do	1,216	1,183	
198	J. W. Baldwin	....do ...	1 N.	5 E.	29	1901	....do ...	34	.....	.....	Yes...	Yes...	.....do	1,216	.....	Do.
200	G. Kleinman	....do ...	1 N.	5 E.	29	.....	....do ...	28	.....	Yes...	Yes...	.....	.....do	1,217	.....	Do.
201	J. P. Huber	....do ...	1 N.	5 E.	29	1893	....do ...	34	33	Yes...	No....	Yes...	.....do	1,216	1,183	
202	A. P Kleinman	....do ...	1 N.	5 E.	29	1885	....do ...	38	.....	Yes...	No....	.....	.....do	1,220	.....	Do.
204	Geo. Patterson	.....	1 N.	5 E.	29	1901	....do ...	42	41	.....	Yes...	Yes...	.....do	1,222	1,181	
216	.....	.....	1 N.	5 E.	29	.....	....do ...	36	.....	Yes...	Yes...	.....	.....do	1,220	.....	Do.
218	James Biddlecome	Tempe .	1 N.	5 E.	29	1901	....do ...	34	33	Yes...	No....	Yes...	.....do	1,210	1,177	Decreasing.
222	Arthur Openshaw	....do ...	1 N.	5 E.	29	1898	....do ...	30	29	Yes...	.....	.....	.....do	1,207	1,178	
226	George Way	.....	1 N.	5 E.	29	.....	....do ...	21	.....	.....	.....	.....	.....do	1,205	.....	Dry.
242	R. D. Rosenberger	Mesa ...	1 N.	5 E.	29	.....	....do ...	31	30	Yes...	No....	No....	.....do	1,208	1,178	
243	Thos. Stapley	....do ...	1 N.	5 E.	29	1886	....do ...	33	31	Yes...	.....	Yes...	.....do	1,210	1,179	
133	J. M. Roundtree	....do ...	1 N.	5 E.	29	.....	....do ...	29	28	.....	Yes...	.....	.....do	1,205	1,177	
171	Frank Johnson	Tempe .	1 N.	5 E.	30	1896	....do ...	22	20	Yes...	No....	Yes...	.....do	1,203	1,181	
172	.....do	....do ...	1 N.	5 E.	30	1895	....do ...	25	.....	Yes...	No....	Yes...	.....do	1,202	.....	
174	B. F. Johnson	....do ...	1 N.	5 E.	30	1897	....do ...	33	22	Yes...	Yes...	Yes...	.....do	1,200	1,178	
175	.....do	....do ...	1 N.	5 E.	30	1885	....do ...	24	23	Yes...	Yes...	Yes...	.....do	1,200	1,177	
219	E. C. Openshaw	....do ...	1 N.	5 E.	30	1895	....do ...	32	31	Yes...	No....	No....	.....do	1,207	1,176	
220	School No. 29	....do ...	1 N.	5 E.	30	.....	....do ...	20	.....	.....	.....	.....	.....do	1,207	.....	Do.
221	D. C. Brimhall	Mesa ...	1 N.	5 E.	30	1892	....do ...	30	29	Yes...	No....	Yes...	.....do	1,207	1,178	
223	S. Openshaw	Tempe .	1 N.	5 E.	30	1892	....do ...	30	28	Yes...	Yes...	Yes...	.....do	1,206	1,178	

Tabulation of shallow wells—Continued.

MESA TOWNSHIP (T. 1 N., R. 5 E.)—Continued.

Number.	Owner.	Post-office.	Location.			Completed.	How put down.	Depth of well.	Depth to water.	Does water vary at different times of year?	Is water easily lowered?	Did water rise when struck?	Has the volume of water increased or diminished?	Elevation of surface.	Elevation of water.	Remarks.
			Township.	Range.	Section.											
								Feet.	*Feet.*					*Feet.*	*Feet.*	
224	R. Holliday	Mesa	1 N.	5 E.	30		Dug	29	28	Yes	Yes	Yes	Diminished	1,206	1,178	Dry.
225	Wm. C. Parks	do	1 N.	5 E.	30	1892	do	28	27	Yes	Yes	No	do	1,205	1,180	
227	Don Le Baron		1 N.	5 E.	30	1894	do	29	27	Yes	Yes	Yes	do	1,204	1,177	
228	Peter Lawson	Tempe	1 N.	5 E.	30	1896	do	28	27	Yes	No		do	1,203	1,176	
229	J. E. Johnson		1 N.	5 E.	30	1890	do	22	20	Yes			do	1,201	1,181	
230	Frankenburg Bros	Tempe	1 N.	5 E.	30	1902	do	25	21	Yes	No		do	1,195	1,174	
233	do	do	1 N.	5 E.	30	1890	do	27	24	Yes	No	Yes	do	1,198	1,174	
334	do	do	1 N.	5 E.	30	1902	do	24	21	Yes	No	Yes	do	1,193	1,172	
239	R. W. Westover	do	1 N.	5 E.	30	1887	do	31	30	Yes	Yes	No	do	1,205	1,175	
240	Luther Spainhower		1 N.	5 E.	30		do	33	31	Yes	Yes	Yes	do	1,207	1,176	
241	J. H. Spainhower	Tempe	1 N.	5 E.	30	1895	do	33	32	Yes	No	No	do	1,209	1,177	
2	Allison Bros	Mesa	1 N.	5 E.	30	1892	do	55	53	Yes	No	No	do	1,244	1,191	
129	F. T. Powers	do	1 N.	5 E.	31	1896	do	26	23	Yes			do	1,199	1,176	
130	do	do	1 N.	5 E.	31	1894	do	23	22	Yes	Yes	Yes	do	1,199	1,177	
131	Forley Johnson	do	1 N.	5 E.	31		do	22	21		Yes	Yes	do	1,198	1,177	
132	do	do	1 N.	5 E.	31		do	21	20	Yes	Yes		do	1,198	1,178	
161	Ed. Weston	Tempe	1 N.	5 E.	31		do	18						1,197		Do.
168	G. S. Johnson	do	1 N.	5 E.	31		do	21	19	Yes	Yes		Diminished	1,192	1,178	
169	do	do	1 N.	5 E.	31		do	21	19	Yes	Yes		do	1,192	1,173	
173	B. F. Johnson	do	1 N.	5 E.	31	1885	do	24	22	Yes	Yes	Yes	do	1,202	1,180	
134	J. R. Blakely	Mesa	1 N.	5 E.	32		do	29	27		Yes	Yes	do	1,205	1,178	
135	J. S. Standage	Tempe	1 N.	5 E.	32	1899	do	26	25	Yes	Yes	Yes	do	1,204	1,179	
136	A. L. Porter	do	1 N.	5 E.	32	1898	do	26	25	Yes	Yes	No	do	1,203	1,178	
137	Arthur Porter	Mesa	1 N.	5 E.	32		do	26			Yes	No	do	1,210		Do.

138	Arthur Millet	....do	1 N.	5 E.	32	1888	....do	31	30	Yes	Yes	Yes	.....do	1,210	1,180		
139	Alma Millet	Tempe	1 N.	5 E.	32	1899	....do	31	30	Yes	Yes	Yes	.....do	1,210	1,180		
144	Wm. Dorman	Mesa	1 N.	5 E.	32		....do	30	28	Yes	Yes		.....do	1,209	1,181		
178	P. A. Williams	....do	1 N.	5 E.	32	1897	....do	51	50	Yes	No	No	.....do	1,232	1,182		
127	E. W. Wilbur	....do	1 N.	5 E.	32	1897	....do	28	23	Yes	Yes	Yes	.....do	1,201	1,176		
141	S. W. J. Bowen	....do	1 N.	5 E.	33	1899	....do	32	31	Yes	Yes		.....do	1,211	1,181		
142	Mrs. Ingrams	....do	1 N.	5 E.	33		....do	30	29	Yes	Yes	Yes	.....do	1,209	1,180		
143	Herman Priestly	Tempe	1 N.	5 E.	33		....do	27						1,209			Do.
145	.....do	....do	1 N.	5 E.	33		....do	28	27	No	Yes		Diminished	1,209	1,182		
146	.....do	....do	1 N.	5 E.	33		....do	25						1,209			Do.
147	John Hibbert	Mesa	1 N.	5 E.	33	1900	....do	29	28	Yes			Diminished	1,208	1,180		
148	D. T. Hibbert	....do	1 N.	5 E.	33	1890	....do	28	26	No	Yes	No	.....do	1,208	1,182		
149			1 N.	5 E.	33		....do	28	27				.....do	1,209	1,182		
150	Robert Hornbeck	Mesa	1 N.	5 E.	33	1893	....do	30	28	Yes	No	Yes	.....do	1,211	1,183		
151	Leonard Metz	Tempe	1 N.	5 E.	33		....do	33	32	Yes	Yes		.....do	1,213	1,181		
152	.....do	....do	1 N.	5 E.	33		....do	33	32	Yes	Yes		.....do	1,213	1,181		
153	Robert Hornbeck	Mesa	1 N.	5 E.	33	1890	....do	33		Yes	Yes	Yes	.....do	1,214			Do.
154	.....do	....do	1 N.	5 E.	33	1902	....do	33	32	Yes	Yes	Yes	.....do	1,215	1,183		
155	.....do	....do	1 N.	5 E.	33	1896	....do	30					.....do	1,215			Do.
156	E. Pomeroy	....do	1 N.	5 E.	33	1901	....do	32	31	Yes	Yes		.....do	1,215	1,184		
157	.....do	....do	1 N.	5 E.	33	1900	....do	34	32	Yes	Yes	Yes	.....do	1,215	1,183		
158	.....do	....do	1 N.	5 E.	33	1899	....do	34	32	Yes	Yes	Yes	.....do	1,215	1,183		
159	J. D. Hibbert	....do	1 N.	5 E.	33	1902	....do	26					.....do	1,206			Do.
16	H. E. Dana	....do	1 N.	5 E.	33	1888	....do	35						1,216			Do.
17	Theresa Martinez	....do	1 N.	5 E.	33	1894	....do	35						1,215			Do.
18	George Scott	....do	1 N.	5 E.	33	1896	....do	30	27	Yes	Yes	Yes	Diminished	1,210	1,183		
19	.....do	....do	1 N.	5 E.	33	1890	....do	35						1,210			Do.
20	.....do	....do	1 N.	5 E.	33	1890	....do	34	33	Yes	Yes	Yes	Diminished				
59	S. Bacca	....do	1 N.	5 E.	34		....do	30	28				.....do	1,213	1,185		
2	H. D. Evans	....do	1 N.	5 E.	35	1898	....do	52	52	Yes	Yes		.....do	1,221	1,169		
6	R. M. Moore	....do	1 N.	5 E.	35	1892	....do	44	43	Yes	Yes		.....do	1,214	1,171		
8	P. B. Hughes	....do	1 N.	5 E.	35	1892	....do	30						1,220			Do.

Tabulation of shallow wells—Continued.

TOWNSHIP 1 NORTH, RANGE 6 EAST.

[Records obtained by Robert Muldrow.]

Number.	Owner.	Post-office.	Location. Township.	Range.	Section.	Completed.	How put down.	Depth of well.	Depth to water.	Does water vary at different times of year?	Is water easily lowered?	Did water rise when struck?	Has the volume of water increased or diminished?	Elevation of surface.	Elevation of water.	Remarks.
								Feet.	*Feet.*					*Feet.*	*Feet.*	
1	N. H. Wallace	Mesa	1 N.	6 E.	19	1893	Dug	57	55	Yes	Yes	Yes	Neither	1,231	1,196	
3	Doctor Toney	Phoenix	1 N.	6 E.	30	1893	do	60	57	Yes	Yes	No	Diminished	1,251	1,194	
4	Fred Weeks	Mesa	1 N.	6 E.	30	1900	do	45	44	Yes	Yes	No	do	1,239	1,195	
5	E. W. Wilbur	do	1 N.	6 E.	31	1900	do	50	47	No	No	No	Neither	1,237	1,193	
6	Wm. Eruirn	do	1 N.	6 E.	31	1898	do	50	48	Yes	Yes	No	Diminished	1,243	1,195	
7	Dorman Bros	do	1 N.	6 E.	33	1898	do	100	70	Yes	No	Yes	Neither	1,267	1,197	

TOWNSHIP 2 NORTH, RANGE 5 EAST.

5	F. L. Warner	Phoenix	2 N	5 E.	8	1903	Drilled	120	100			Yes		1,199	1,099	
1	Indian	Mesa	2 N.	5 E.	21		Dug	61	60					1,263	1,203	
9	Church	Lehi	2 N	5 E.	29		do	45	43					1,243	1,200	
12	Indian	do	2 N	5 E.	31		do	37	36					1,231	1,195	
368	do	do	2 N	5 E.	31		do	31	30					1,221	1,191	
3	do	Mesa	2 N	5 E.	32		do	33	32					1,226	1,194	
10	do	Lehi	2 N	5 E.	32		do	36	35					1,230	1,195	
11	do	do	2 N	5 E.	32		do	39	38					1,233	1,195	
	Indian school	do	2 N	5 E.	32	1899	do	30	29	Yes	No	No	Diminished	1,220	1,191	Constantly lowered.
	Indian mission	do	2 N	5 E.	32		do	32	30	Yes	No	No	do	1,220	1,190	
	Indian	do	2 N	5 E.	32		do	27	26	Yes	No		do	1,218	1,192	
	do	do	2 N	5 E.	32		do	29	28					1,217	1,189	

367	....do....	Lehi.....	2 N.	5 E.	32	.....	Dug	20	28	.....	.....	.....	.....	1,236	1,192
2	....do....	....do....	2 N.	5 E.	33	.....	....do...	40	38	.....	.....	.....	.....	1,235	1,197
4	....do....	....do....	2 N.	5 E.	33	.....	....do...	40	39	.....	.....	.....	.....	1,238	1,199
5	....do....	....do....	2 N.	5 E.	35	.....	....do...	38	37	.....	.....	.....	.....	1,237	1,200
6	....do....	....do....	2 N.	5 E.	35	.....	....do...	40	37	.....	.....	.....	.....	1,240	1,203
	....do....	....do....	2 N.	5 E.	35	.....	....do...	36	35	Yes...	No....	No....	Diminished ..	1,233	1,198
7	Day school....	....do....	2 N.	5 E.	36	.....	....do...	44	42	.....	.....	.....	.....	1,242	1,200
8	Mission	....do....	2 N.	5 E.	36	.....	....do...	45	44	.....	.....	.....	.....	1,245	1,201

TOWNSHIP 1 SOUTH, RANGE 5 EAST.

	M. Barclay.....	Mesa	1 S.	5 E.	1	1890	Dug	36	.....	.....	.....	.....	.....	1,227	.....	Dry.
	Highland school....	....do....	1 S.	5 E.	2	1899	....do...	53	52	Yes...	Yes...	No....	Diminished ..	1,221	1,169	
	Wm. Newell	....do....	1 S.	5 E.	3	1900	....do...	30	26	Yes...	Yes...	.....	....do.....	1,212	1,186	
	C. W. Davisson....	....do....	1 S.	5 E.	3	.....	....do...	35	25	.....	.....	.....	.....	1,208	1,183	
	S. Hall	....do....	1 S.	5 E.	3	1899	....do...	26	25	.....	.....	.....	Diminished ..	1,211	1,186	
	Michael Fricker	....do....	1 S.	5 E.	4	1899	....do...	24	.....	Yes...	Yes...	Yes...	....do.....	1,206	.....	Do.
	G. A. Dobson.....	....do....	1 S.	5 E.	5	1888	....do...	27	25	Yes...	Yes...	.....	....do.....	1,203	1,178	
	....do.....	....do....	1 S.	5 E.	5	1897	....do...	27	23	Yes...	Yes...	Yes...	Neither.....	1,202	1,179	
	Andrew Housten....	....do....	1 S.	5 E.	5	.....	....do...	25	24	Yes...	Yes...	.....	Diminished ..	1,200	1,176	
	Thos. Argue.....	Tempe	1 S.	5 E.	6	1890	....do...	19	.....	.....	.....	.....	....do.....	1,198	.....	Do.
	....do.....	....do....	1 S.	5 E.	6	1893	....do...	23	22	Yes...	No....	No....	....do.....	1,197	1,175	
	....do.....	....do....	1 S.	5 E.	6	1890	....do...	21	20	Yes...	No....	No....	....do.....	1,196	1,176	
	G. S. Johnson	....do....	1 S.	5 E.	6	1898	....do...	22	21	Yes...	Yes...	Yes...	....do.....	1,194	1,173	
	Chas. Pine	Mesa	1 S.	5 E.	12	1893	....do...	45	43	No....	No....	Yes...	Neither.....	1,230	1,187	Very salty.

TEMPE TOWNSHIP (T. 1 N., R. 4 E.).

5	F. L. Warner	Tempe.....	1 N.	4 E.	8	1903	Drilled .	120	100	.....	.....	.....	.....	1,199	1,099	
6	.....	.....	1 N.	4 E.	9	.....	....do...	125	42	.....	.....	.....	.....	1,173	1,131	
2	J. D. Cooper.....	Tempe.....	1 N.	4 E.	9	1900	Dug	22	18	.....	.....	No....	.....	1,158	1,140	
370	Indian	.....	1 N.	4 E.	12	.....	....do...	15	12	.....	.....	.....	.....	1,185	1,173	
1	T. J. Parry	Tempe.....	1 N.	4 E.	14	1902	....do...	21	17	.....	.....	No....	.....	1,170	1,158	
4	J. H. Commings	....do....	1 N.	4 E.	15	1902	....do...	17	16	.....	.....	No....	.....	1,150	1,134	

Tabulation of shallow wells—Continued.

TEMPE TOWNSHIP (T. 1 N., R. 4 E.)—Continued.

Number.	Owner.	Post-office.	Location. Township.	Range.	Section.	Completed.	How put down.	Depth of well.	Depth to water.	Does water vary at different times of year?	Is water easily lowered?	Did water rise when struck?	Has the volume of water increased or diminished?	Elevation of surface.	Elevation of water.	Remarks.
								Feet.	*Feet.*					*Feet.*	*Feet.*	
3	J. D. Cooper	Tempe	1 N.	4 E.	16	1899	Dug	19	18					1,155	1,137	
9	J. Sturgeon	do	1 N.	4 E.	16	1892	do	13	8			No		1,152	1,144	
	Francisco Peralta	do	1 N.	4 E.	16	1894	do	28	25			No		1,153	1,128	
11	Sisto Valdez	do	1 N.	4 E.	16	1901	do	18	16			No		1,150	1,134	
12	G. Mindose	do	1 N.	4 E.	16	1901	do	16	14			No		1,152	1,138	
14			1 N.	4 E.	16	1899	do	16	15			No		1,152	1,137	
15	R. Veltron	Tempe	1 N.	4 E.	16	1892	do	18	16			No		1,152	1,136	
16	—— Gonzalles	do	1 N.	4 E.	16	1898	do	28	18			No		1,155	1,137	
17	Francisco Vajeco	do	1 N.	4 E.	16	1891	do	20	18			No		1,148	1,130	
18	Mrs. Jones	do	1 N.	4 E.	17	1898	do	18	16			No		1,144	1,122	
19	J. T. Priest	do	1 N.	4 E.	20	1889	do	14	12			No		1,144	1,132	
	A. R. Jenkins	do	1 N.	4 E.	20		do		10							
231	Frankenburg Bros	do	1 N.	4 E.	25	1901	do	24	20	Yes	No	Yes	Diminished	1,193	1,173	
232	C. G. Jones	do	1 N.	4 E.	25	1901	do	24	23	Yes	Yes	No	do	1,196	1,173	
	J. W. Johnson	do	1 N.	4 E.	27	1902	Drilled	25								
	Niels Peterson	do	1 N.	4 E.	28		Dug		18							
	do	do	1 N.	4 E.	29	1893	do	25	20			No		1,138	1,118	
	J. P. Jensen	do	1 N.	4 E.	29		do	31	26			No		1,139	1,113	
20	A. H. Brown	do	1 N.	4 E.	31	1899	do	52	49			Yes		1,175	1,126	
	Byron Carr	do	1 N.	4 E.	31		do		32							
	—— Tobin	do	1 N.	4 E.	32				29					1,152	1,123	

21	George W. Nichols	Tempe	1 N.	4 E.	34	1897	Dug	15	8			No		1,178	1,170
165	C. M. Mullen	do	1 N.	4 E.	36	1890	do	22	20	Yes	Yes		Diminished	1,194	1,174
166	do	do	1 N.	4 E.	36	1901	do	22	20	Yes	Yes	Yes	do	1,194	1,174
167			1 N.	4 E.	36		do	13	10					1,194	1,184

TOWNSHIP 2 NORTH, RANGE 4 EAST.

[Records obtained by R. W. Hawley.]

7	F. F. Titus	Tempe	2 N	4 E.	2	1895	Dug	31	29			No		1,215	1,186
8	H. L. Underhill	Scottsdale	2 N	4 E.	22	1897	do	75	66			No		1,261	1,195
9	E. M. Toleman	do	2 N	4 E.	22	1903	do	75	67			Yes		1,262	1,194
10	Chaplin Scott	do	2 N.	4 E.	23		do	67	65			No		1,260	1,195
11			2 N.	4 E.	24		do	69	69			No		1,253	1,184
	W. J. Murphey	Phoenix	2 N	4 E.	27		do	67	56			No		1,250	1,194
12	do	do	2 N.	4 E.	30	1894	Drilled	98	66			Yes		1,214	1,148
	Thos. Murphey	do	2 N.	4 E.	30	1902	do	325	72			Yes		1,197	1,125
1	Mary Showers	Scottsdale	2 N.	4 E.	36	1901	Dug	40	38			No		1,229	1,191
2	do	do	2 N.	4 E.	36	1900	do	38	37			No		1,227	1,190
3	Wilfred Hayden	Phoenix	2 N.	4 E.	36	1894	do	38	37			No		1,226	1,189
4	Frank Titus		2 N.	4 E.	36	1901	do	60	50			Yes		1,224	1,174
5	Poor ranch	Phoenix	2 N.	4 E.	36	1898	do	40	39			No		1,232	1,192
6			2 N.	4 E.	36		do	26	25			No		1,215	1,190
13	S. W. Ney	Scottsdale	2 N.	4 E.	36	1897	do	38	36			No		1,227	1,191
14	do	do	2 N.	4 E.	36	1903	do	38	36			No		1,227	1,191

Throughout the Mesa region, wherever special inquiry was made, it was found that the surface of the underground water has been continually lowering for years. Wells which were formerly productive throughout the year are now dry for a part or all of the year. With few exceptions the wells have been lowered in order to obtain sufficient water. This lowering of the water has been progressive and wells have been deepened repeatedly. In the vicinity of Tempe the water has lowered about 7 feet. Near Mesa it has lowered much more. According to Code's[a] measurement in 1901, the normal water level at the Murphy-McQueen pumping plant was 22.5 feet below the land surface (see fig. 2, p. 14). On January 19, 1904, this level was found at the same place to be 34 feet below the land surface. At certain places the lowering is reported as 20 feet or even more.

While the underground water supply of the valley has been decreasing for a number of years, there are yearly variations depending more or less directly upon the abundance of surface waters. Certain wells are dry during the dry seasons and contain water during the seasons of more abundant supply. The term "rainy season" is purposely avoided, the seasons of more abundant surface waters being those in which an increased supply enters the valley in streams. The rains in the valley itself are so slight that they have no effect that can be detected in the wells.

THE PHOENIX REGION.

PHOENIX WATER COMPANY'S WELLS.

Previous to 1902 the city of Phoenix was supplied with water from two dug wells, 42 feet deep, which had, when measured, 10 feet of water. During the exceptionally dry season of 1902 the water in these wells failed and three 12-inch double-steel-cased wells were drilled to a depth of 208 feet. An abundant water supply was found at a depth of 55 feet, and thence downward to 208 feet were continuous water-bearing gravels and bowlders. The water from the open wells comes from the upper gravels indicated in the log, and that from the drilled wells comes from the lower gravels. At the time of my visit to the plant water from one open well and one drilled well was supplying the city at the rate of about 1,750 gallons per minute. It is said that one of the drilled wells alone has yielded water at this rate.

Log of well of Phoenix Water Company, near Phoenix.

	Feet.
Soil	13
Gravel and bowlders, water bearing	36
Clay and cement	7
Gravel and bowlders, water bearing	153

[a] Code, W. H., Report of irrigation investigations for 1901, No. 1: U. S. Dept. Agric., Bull. 119, 1902, p. 67.

Unfortunately there was no opportunity of obtaining satisfactory pumping tests at this plant. The amount named, 1,750 gallons per minute, is estimated from the time it takes to fill the standpipe.

As in the case of the well at the asylum and other wells to be described later there is no marked difference between the upper and lower water bodies, although the two are separated by 7 feet of clay and cement. No. 3, in the table below, is an analysis of water from the upper water body and No. 4 from the lower body. The samples were taken directly from the wells at a time when the pumps were in operation.

Much interest is taken by the water users of the valley in the supposed improvement in the quality of the water as the wells are used. Reference has been made to such an improvement in case of the Chandler wells and others. Four analyses of the Phoenix city supply have been made, as indicated below. The three analyses representing the shallow wells extend over a period of about 5.5 years. Since this water supplies the city the draft on the wells is constant, and if use will materially improve the quality of wells, this water should show an improvement. On the contrary, the latest analyses indicate a marked increase in the quantity of soluble salts.

Analyses of water from the Phoenix Water Company's wells.

	1. Dug well, Sept. 18, 1898.	2. Dug well, May 9, 1902.	3. Dug well, May 14, 1903.	4. Drilled well, May 14, 1903.
Quantitative (parts in 100,000):				
Total solids soluble at 110° C.	116.8	102.4	136.00	132.00
Chlorine in terms of NaCl (common salt)	72.5	54.6	80.80	77.60
Hardness in terms of $CaSO_4$ (sulphate of lime)	Strong.	8.98	6.53	5.44
Alkalinity in terms of Na_2CO_3 (black alkali)			.00	.00
Nitrogen in the form of nitrates	.10	.16	.25	.25
Nitrogen in the form of nitrites	.0007	.0045	.02	Very faint.
Qualitative:				
Sulphates		Very strong.	Pronounced.	Pronounced.
Magnesia		Very strong.	Pronounced.	Pronounced.
Lime		Very strong.	Strong.	Strong.
Bicarbonates			Strong.	Very strong.

PHOENIX LIGHT AND FUEL COMPANY'S WELL.

This company has a single 12-inch double-steel-cased well at the power house in Phoenix. The well is 194 feet deep, with water at a depth of 31 feet. Below a depth of 46 feet, 16 feet of clay and cement occur. Otherwise, throughout the entire depth of the water-bearing portion, the material is coarse and wholly unconsolidated.

Log of Phoenix Light and Fuel Company's well.

	Feet.
Soil	15
Gravel, water in the lower part	31
Cement	2
Clay	11
Cement	3
Quicksand	3
Sand, gravel, and bowlders, water bearing	129

A shaft has been sunk to near water level and cemented to exclude any moisture from without. At the bottom of this shaft is placed the centrifugal pump and 50-horsepower electric motor. The water is used for condensing steam in the power house, after which it is used for irrigation.

A careful pumping test was made at this plant under the direction of Mr. D. W. Beldon, the engineer in charge, with results given below. It will be noted that in this case a single 12-inch well is yielding 1,995 gallons of water per minute continuously, with a local depression of the water table of little more than 16 feet.

Report of test on electrically driven centrifugal pump for irrigation.[a]

[Test made January 10, 1904, by D. W. Beldon, electrical engineer.]

Motor (3 phase; 350 volt; 60 cycle) speed	r. p. m.	720
Pump (direct-connected centrifugal; 10-inch suction; 8-inch discharge) r. p. m		720
Height; pump center above water (still)	feet	5⅓
Vacuum; pump running	inches	20
Water lowered by pump running (22 feet − 5⅓ feet)	feet	16⅔
Head above vacuum gauge	do	19
Total head (less friction and velocity of discharge)	do	41
Water pumped per minute	cubic feet	266
Total power absorbed by motor	kilowatts	38.6
Kilowatt hours required per acre-foot		105+
Cost of power per acre-foot (2 cents per kilowatt hour)		$2.10
Cost of power per acre-foot (per foot of lift)		$0.0512

PERKINS WELL (SEC. 23, T. 2 N., R. 3 E.).

Mr. C. W. Perkins has a 10-inch drilled well 155 feet deep. The water surface is 83 feet below the surface of the ground. The well is

[a] This report did not reach the writer in time to be included in the computations of cost described in the following chapters. The cost does not differ materially from that of other well-equipped pumping plants.

ated at Mr. Perkins's olive-oil factory, and the water is used for igating his olive and orange orchards during dry times when ditch ater can not be obtained. The distance through which the water ust be raised (a minimum of 83 feet) prohibits its economic use xcept as a last resort. Before the well was put down the lack of water in the irrigation canals at critical times caused serious damage to the fruit and even the death of a large number of trees. Costly as it is to pump from such a depth, water at a critical time is worth much more than it costs in saving valuable crops that might otherwise be injured or wholly destroyed. The well yields about 200 gallons per minute. The water is lifted by means of a deep-well pump, operated by a gasoline engine.

Analysis of water from C. W. Perkins's well.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C.	83.60
Chlorine in terms of NaCl (common salt)	30.80
Hardness in terms of $CaSO_4$	8.30
Alkalinity in terms of Na_2CO_3	.00
Nitrogen in the form of nitrates	.53
Nitrogen in the form of nitrites	.871
Qualitative:	
Sulphates	Very strong.
Magnesia	Strong.
Lime	Strong.

PHOENIX MACHINE AND COLD STORAGE COMPANY'S WELL.

The well is located at the company's factory in Phoenix, and was put down in December, 1903. It is a 12-inch double-steel-cased well 125 feet deep. Only 5 feet of fine material was encountered at the surface, all below this being entirely loose sand, gravel, and bowlders. Water is raised by means of a deep-well cylinder pump, but since no great supply is required the capacity of the well is not known.

Log of Phoenix Machine and Cold Storage Company's well.

	Feet.
Soil	5
Sand and bowlders slightly cemented	12
Sand, gravel, and bowlders, water bearing	118

BARTLETT-HEARD LAND AND CATTLE COMPANY'S WELLS (SEC. 30, T. 1 N., R. 4 E.).

An extensive pumping plant has been planned for this company for the purpose of obtaining an auxiliary water supply for a large tract of land lying south of Phoenix. A battery of six 15-inch double-steel-cased wells has been established, but the machinery is not installed at this writing. A depth of 28 feet of soil was penetrated, and water-bearing bowlders were encountered to a depth of 90 feet. The bowl-

ders are underlain by granitic wash, 10 feet of which was penetrated. The water-bearing material is coarse and unconsolidated. Numerous quartzite bowlders up to 1 foot in diameter were taken from the well in drilling. The water is under no pressure and its surface does not even reach the top of the gravel bed, resting at a depth of 32.5 feet. On account of the limited thickness of the gravel bed drilling was suspended after the completion of the second well and a preliminary pumping test was made under the direction of Mr. Fuller, the engineer in charge, in order to determine whether the available quantity of water would justify the establishment of the plant at this place.

Log of Bartlett-Heard Land and Cattle Company's well No. 3.

	Feet.
Sand and soil	28
Gravel and bowlders, water bearing	62
Granite wash	10

The perforated areas of the wells differed in the proportion of 3 to 5, and the one having the smaller perforation area was tested, on the assumption that if it proved satisfactory there could be no question regarding those having better perforations. A shaft was dug to water level and a small centrifugal pump placed at the bottom and belted to an 18-horsepower traction engine at the surface. The pump was operated 2.5 hours and readings were taken every ten minutes. It discharged an average of 78.8 miner's inches of water (886 gallons per minute) and lowered the water in the well 19 feet and 8 inches (fig. 10). The water in the second well, 15 feet from the one tested, was lowered only 2 feet. Within thirty seconds after the pump stopped the water rose to the normal level. A lighter demand makes correspondingly less depression of the water table and therefore a lower lift. The same effect is also obtained by better perforation of the casing. The present lift of 53 feet can probably be materially lessened and the desired quantity of water can be still obtained by sinking a number of properly perforated wells.

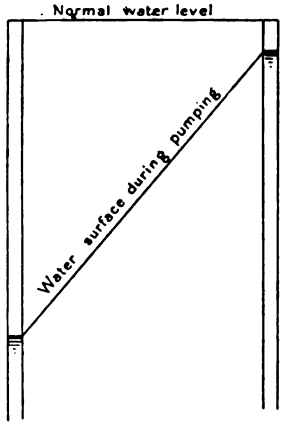


FIG. 10.—Depression of water table during pumping test of the Bartlett-Heard well.

Analysis of water from the Bartlett-Heard Land and Cattle Company's well.

[Sample taken during the pumping test, February 4, 1904.]

Quantitative (parts in 100,000):	
Total solids soluble at 110° C.	194.0
Chlorine in terms of NaCl (common salt)	126.0
Hardness in terms of $CaSO_4$ (sulphate of lime)	5.44
Alkalinity in terms of Na_2CO_3 (black alkali)	None.
Nitrogen	None.

Qualitative:

Sulphates	Strong.
Magnesia	Strong.
Lime	Strong.
Bicarbonates	Very strong.

WELL AT THE TERRITORIAL ASYLUM FOR THE INSANE (SEC. 2, T. 1 N., R. 3 E.).

The asylum is situated about 3 miles east of Phoenix on the Phoenix-Tempe road. A shaft 12 by 14 feet and 22.5 feet deep is tightly bricked and cemented to shut out any surface water which might seep in. From the bottom of this shaft a 12-inch well was sunk 87.5 feet, or 110 feet below the surface of the ground. At a depth of 57 feet the water-bearing gravel was struck, but the supply of water is not as great as in other wells entering what is presumably the same gravel bed. This may possibly be due to imperfections of construction; only the lower 24 feet of the pipe are perforated, and these perforations were made before the casing was forced into the well. After the pipe was in place the well was "shot." This increased the available supply to a quantity sufficient for the present needs of the asylum, but the yield is not yet as great as might reasonably be expected.

Log of asylum well, near Phoenix.

	Feet.
Soil	12
Gravel, water bearing	16
Clay and cement	9
Gravel and bowlders, water bearing	53

A steam pump is located at the bottom of the shaft and a suction pipe 24 feet long extends into the well. The engine is usually run at a rate which lifts 95 gallons per minute, and depresses the water surface 5 feet. This has been found to be practically the capacity of the well.

There are two water-bearing horizons in this well separated by 9 feet of clay and cement. Since the casing is perforated only near the bottom, the upper water is shut off, and analysis 1 of the following table is from water of the lower gravels. Analysis 2 is from water of a well 42 feet deep and therefore from the upper body. The great similarity of the analyses indicates that the two water bodies are probably connected.

Analyses of water from the asylum well, near Phoenix.

	No. 1.	No. 2.
Quantitative (parts in 100,000):		
Total solids soluble at 110° C.	126.40	120.40
Chlorine in terms of NaCl (common salt)	78.80	79.20
Hardness in terms of $CaSO_4$ (sulphate of lime)	13.60	8.20
Alkalinity in terms of Na_2CO_3 (black alkali)	None.	None.
Nitrogen in the form of nitrates	Faint.	Faint.
Nitrogen in the form of nitrites	Faint.	Faint.
Qualitative:		
Sulphates	Very strong.	Very strong.
Magnesia	Strong.	Very strong.
Lime	Strong.	Very strong.
Bicarbonates		

PHOENIX INDIAN SCHOOL WELLS (SEC. 20, T. 1 N., R. 3 E.).

There are three deep wells at the Indian School, one at the power house and two, designed for irrigation, some distance from the school buildings. The well at the power house is 193 feet deep and 6 inches in diameter. The water is used to supply the school buildings and lawns and is pumped at the rate of about 60 gallons per minute.

The first irrigation well is dug to a depth of 56 feet. From the bottom of this pit two 6-inch holes have been drilled, the first 145 feet and the second 338 feet in depth. The water stands 36 feet beneath the surface. It was the original plan to cut the well casing at the bottom of the open part and allow the water to flow from the drilled wells into the open well, from which it was to be lifted by a bucket pump.

Log of Phoenix Indian School irrigation well No. 1.

	Feet.
Soil and cement	40
Sand, cemented in places	40
Hard, white cement	15
Quicksand	6
Sandy clay	66
Sand, water bearing	26
Alternating beds of sand, clay, and cement (no definite record)	62
Cement	20
Cemented sand	24
Granite wash, water bearing	12
Sand and gravel	12
Cemented sand	8
Sand and gravel, water bearing	9
Gravel and bowlders, water bearing	3

The material passed through gave promise of comparatively little water. A gravel bed was encountered at the depth of 335 feet, but

since the casing was not extended to the bottom no headway could be made in the loose gravels, and the drilling was abandoned for a time. The gravel bed at the bottom is promising, but its thickness and character are unknown. At a preliminary pumping test only 10 inches of water was obtained.

The well is supplied temporarily with a bucket pump operated by an electric motor. When running at ordinary speed, the pump discharges about 200 gallons of water per minute and soon drains the open well. A discharge of about 100 gallons per minute maintains the water level at 52 feet, a depression of 16 feet, thus indicating the practical capacity of the well. During the time that the water surface was held at a depth of 52 feet the water flowed from the top of the drilled wells into the open part, but without any great force. The rate of discharge is slow, and the outlook for an underground supply is not encouraging.

A good example of the depression of the water table is found at this place. In the year 1895 a well at the Indian School encountered water at a depth of 16 feet. The same well, deepened as the water surface lowered, in January, 1904, contained water at a depth of 38 feet—a depression of 22 feet in about eight years.

Log of Phoenix Indian School irrigation well No. 2.

	Feet.
Soil, sand, and cement	85
Sand, water bearing	14
Cemented sand	40
Putty clay	30
Sand	10
Putty clay	16
Sand and gravel	30
Red sandstone	3

A third well has been put down on the Indian School farm 1 mile east of the school. It is a 6-inch drilled well 228 feet deep. An incident occurred in drilling this well which has an important bearing on the quantity of water to be expected in this vicinity. Water was found at a depth of about 51 feet and rose 15 feet, keeping the well filled until a sand stratum was encountered at a depth of about 170 feet. The water from above entered this sand and lowered the surface of the water in the well to about 100 feet—a depression of about 64 feet. This level was maintained, the sand absorbing the entire flow from the higher water horizons until the leakage was stopped by clay pounded into the loose sand by the action of the drill.

This well is slightly more promising than No. 1, but no test has been made. The red sandstone at the bottom is probably the breccia exposed at the surface farther to the east and north.

Analyses of water from wells at the Phoenix Indian School.

	No. 1 (45 feet).	No. 2 (145 feet).	No. 3 (15 feet).	No. 4 (60 feet).
Quantitative (parts in 100,000):				
Total solids soluble at 110° C	245.20	250.00	222.00	362.30
Chlorine in terms of NaCl (common salt)	160.80	145.00	141.00	258.00
Hardness in terms of $CaSO_4$ (sulphate of lime)	21.80	65.80	None.	Strong.
Alkalinity in terms of Na_2CO_3 (black alkali)	None.	None.	33.36	None.
Nitrogen in the form of nitrates	.40	.25	Faint.	.30
Nitrogen in the form of nitrites	Faint traces.	.00	.0008	.0028
Qualitative:				
Sulphates			Very strong.	Very strong.
Magnesia			Very strong.	Very strong.
Lime			Very strong.	Very strong.
Bicarbonates			Strong.	Strong.

G. W. SMITH'S WELL (SEC. 10, T. 1 N., R. 3 E.).

This well is dug 20 by 40 feet, 38 feet deep, and has 8 feet of water. The lower half of the well is in coarse sand, gravel, and bowlders, and required careful timbering to keep the sides from caving in. It was the material from this well which was used in the experiment described later under the caption of "practical porosity." The water is raised by means of a 12-horsepower gasoline engine and 6-inch horizontal centrifugal pump, at the rate of about 50 inches (564 gallons) per minute. The water is used for irrigation.

THE KUNZ WELL (SEC. 18, T. 1 N., R. 3 E.).

The well of Dr. R. E. Kuntze and L. Kunz & Sons is 6 by 6 feet, 24 feet deep, and has 6 feet of water. It was begun in 1899 and has since been lowered, but the water is now gradually rising. It is used for irrigating a botanical garden containing various kinds of shrubs, trees, and flowers. Since 1899 the garden has been irrigated with no other water.

The pump is a novel invention of one of the owners of the place and has comparatively high efficiency. The essential part of the mechanism is a light walking beam about 12 feet long hinged at the center,

with its extremities traveling over a sinuous track. Near the center of the walking beam is placed a system of levers which operate two suction pumps. A mule is hitched to the pump in the ordinary manner, and when properly blindfolded works without a driver. As the machine is turned the walking beam is made to oscillate in a vertical plane by means of the sinuous track, and thus works the pumps.

The comparative ease with which water is raised by this machine and the claim that horsepower is cheaper than gasoline or steam led to a careful measurement of the amount pumped and the computation of cost as given below. The value of the mules employed is probably exaggerated; more valuable animals would do correspondingly more work. The pasturage is counted at $1.50 per month for each animal and feed at $1.30 per month.

Cost of pumping by mule power at the Kunz yard.

Cost of well and pump	$200.00
Two mules at $25	$50.00
Interest on investment at 7 per cent per annum for 3.6 days	$0.17
Depreciation at 10 per cent per annum for 3.6 days	$0.24
Average amount pumped per minute, in gallons	62
Days required to pump 1 acre-foot	3.6
Pasture and feed for 2 mules at 19 cents per day for 3.6 days	$0.68
Oil and incidentals (estimated)	$0.05
Total cost per acre-foot	$1.14
Lift, in feet	18
Average cost per foot in raising 1 acre-foot of water	$0.063

Analysis of water from the Kunz well.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C	223.00
Chlorine in terms of NaCl (common salt)	146.80
Hardness in terms of $CaSO_4$ (sulphate of lime)	53.70
Alkalinity in terms of Na_2CO_3 (black alkali)	None.
Qualitative:	
Sulphates	Very strong.
Magnesia	Strong.
Lime	Very strong.
Bicarbonates	Very strong.

EAST LAKE PARK WELL.

This well supplies water for a natatorium, for an artificial lake, and for general park use. It is 7 by 10 feet, 42 feet deep, and has 9 feet of water. Water is raised by a bucket pump operated by an electric motor. At the time of my visit to this plant the pump was discharging water at the rate of 210 gallons per minute, and this seemed to be the maximum capacity of the well.

WAGNER WELL (SEC. 16, T. 1 N., R. 3 E.).

Mr. Frank Wagner has a dug well 7 by 7 feet and 35 feet deep, from which he pumps water for the irrigation of his gardens and nursery. The well is provided with bucket pump and horsepower, by means of which water is raised at the rate of about 12 inches (135 gallons) per minute.

WETZLER WELL (SEC. 11, T. 1 N., R. 3 E.).

Lewis Wetzler's well is dug 8 by 8 feet and 40 feet deep, and contains 15 feet of water. Water is raised by means of a bucket pump and a 5-horsepower gasoline engine at the rate of about 35 inches (396 gallons) per minute. This water has been used since 1900 in raising garden produce.

Analysis of water from Lewis Wetzler's well, near Phoenix.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C.	144.00
Chlorine in terms of NaCl (common salt)	86.00
Hardness in terms of $CaSO_4$ (sulphate of lime)	23.90
Alkalinity in terms of Na_2CO_3 (black alkali)	None.
Qualitative:	
Sulphates	Pronounced.
Magnesia	Very faint.
Lime	Strong.

M'CALLUM WELL (SEC. 24, T. 1 N., R. 2 E.).

N. P. McCallum's well is situated on the southern bank of Salt River about 4 miles southwest of Phoenix. It is a dug well 9 feet in diameter and 31 feet deep, walled with brick for the lower 15 feet. Spaces are left in the brick wall to allow the seepage water to enter from the side. The well is dug in the sands and gravels of the river deposit a few feet from the southernmost channel of the river. This channel serves at present as a seepage ditch carrying a small amount of water. This water is led by a subterranean passage into the well and adds materially to the amount available for pumping.

The water stands normally 14 feet below the surface. An 8-inch Byron Jackson centrifugal pump is placed a few feet above the normal water level and operated by a 40-horsepower traction engine. The amount of water pumped at present is estimated at 1,100 gallons per minute. With this yield the water in the well is lowered 12.5 feet, and remains stationary. A heavier demand drains the well.

Mr. McCallum's ditch is arranged to take flood water from the river whenever such water is available. The pump water is discharged into the same ditch. A subway from the pump to the ditch is cut 9.5 feet below the surface. The water is therefore lifted only 17 feet when the pump is discharging 1,100 gallons per minute.

A 12-inch double-steel-cased drilled well has recently been put down at this point. It is 124 feet deep and penetrates nothing but unconsolidated sand, gravels, and bowlders. A preliminary test gave 175 inches of water (1,970 gallons per minute).

Log of N. P. McCallum's drilled well, near Phoenix.

	Feet.
River sand	10
Gravel and bowlders, water bearing	114

COLLINS WELL (SEC. 15, T. 1 N., R. 2 E.).

Mr. George U. Collins's well is situated about 3 miles southwest of Phoenix. It is a large seepage well 100 feet long by 60 feet wide and 29 feet deep. The material encountered for the upper 10 feet is sandy soil and for the remaining 19 feet river gravel and bowlders. When the pump is not running the water rises to within 19 feet of the surface of the ground. The water is raised by a 60-horsepower steam engine and a horizontal centrifugal pump which furnishes a continuous supply day and night of 190 to 200 inches, or about 2,200 gallons per minute. When pumped at this rate the water in the well is lowered 6 feet, at which level the inflow equals the amount pumped and the surface remains stationary. When a greater amount is pumped, the surface of the water is proportionately lowered. (See Pl. V, *B*.)

The bed of gravel and bowlders in which the well is sunk has evidently a somewhat free connection with the underflow of the river. At the time of my first visit to the well the pump had not been in operation for several days, and the water was standing at normal level. There was a distinct current in the well caused obviously by the passage of the underflow through it. The inflowing current was stronger at one end than at the other, resulting in a slow eddying movement of the water bearing the floating material in an endless journey about the well.

Mr. Collins was kind enough to give some figures and facts gleaned from his long experience which may be of benefit to those thinking of constructing similar plants. The cost of digging and casing the well was $11,900—probably more than a similar well would cost in some places. The looseness of the gravel and bowlders and the abundance of water in them make excavation a costly process; it should be noted, however, that easier digging due to more consolidated gravels is likely to be accompanied by a smaller water supply.

The plant has been in operation for three years, and land which is irrigated from it is producing as good, and in some cases better, crops than the neighboring land irrigated with ditch water. This may be due to the fact that pumped water can be applied when needed while ditch water must be used at stated times. While the water is derived wholly from the underflow, the quantity and kinds of salts contained

in it are not such as to warrant the doubt of its utility that exists in the minds of many people in the valley. It will be noted from the following analysis that the total of contained salts is comparatively low and that the greatly feared black alkali is absent.

Analysis of water from George U. Collins's well, near Phoenix

Quantitative parts in 100,000:	
Total solids soluble at 110° C	150.00
Chlorine in terms of NaCl (common salt)	94.80
Hardness in terms of $CaSO_4$ (sulphate of lime)	17.40
Alkalinity in terms of Na_2CO_3 (black alkali)	None.
Qualitative:	
Sulphates	Strong.
Magnesia	Strong.
Lime	Strong.
Bicarbonates	Strong.

Measurements were made at the Collins well for the purpose of computing the cost of pumping. The water was measured in a temporary weir and the quantity given (190 inches) is approximately correct. Leakage at several points occasioned some loss.

Cost of pumping water at the Collins pumping plant.

Cost of well	$11,900.00
Cost of pump and engine	$3,100.00
Interest on $15,000 at 7 per cent per annum for 2.6 hours	$0.31
Depreciation at 10 per cent per annum for 2.6 hours	$0.44
Average discharge of water in inches	190
Average discharge of water in second-feet	4.75
Hours to pump 1 acre-foot	2.6
1.5 cords of wood lasts 14 hours (average).	
Cost of wood for 2.6 hours, at $1.50 per cord[a]	$0.48
Oil and incidentals (estimated)	$0.05
Engineer, 2.6 hours, at 25 cents per hour	$0.65
Total cost per acre-foot	$1.93
Total lift in feet	22
Average cost per foot of raising 1 acre-foot	$0.07
With wood, reckoned at $4 per cord:[a]	
Total cost per acre-foot	$2.75
Average cost per foot of raising 1 acre-foot[a]	$0.124

NELSON & McILWAINE WELLS (SEC. 15, T. 1 N., R. 2 E.).

These wells are located near the river, about 3 miles southwest of Phoenix. There are two, 7 feet in diameter and 26 feet deep, dug side by side and communicating. The water is raised by a 20-horse-

[a] Wood is reckoned at $1.50 per cord; this is its cost of cutting and hauling and not its purchase price. Since fuel is the principal item of expense the purchase price of wood should be counted in order to compare the cost of water at this point with the cost where fuel is purchased in the open market. Four dollars per cord may be considered an average price for the wood used at this plant. This would raise the cost of fuel for 1 acre-foot of water to $1.28 instead of 48 cents and make the total cost per acre-foot $2.75 and the average cost per foot of raising 1 acre-foot of water 12.4 cents in place of 7 cents.

power "Model" gasoline engine and an 8-inch centrifugal pump at the rate of 900 gallons per minute. The water surface is 16 feet below the surface of the ground at present, but varies with the water in the river. At the time of my visit the water was abundant in the river, and the water in the wells was lowered only 5 feet by pumping. During dry seasons, when there is little water in the river, the water stands at a lower level in the wells and the pump lowers it more easily, and even drains the wells. The quantity of water is also affected by the irrigation of lands in the vicinity, being noticeably more abundant in the wells during times of extensive or continued irrigation. The supply drawn from by this pumping plant is therefore due to seepage, partly from the underflow of the river and partly from the return waters from irrigated lands.

The well water is found to be very useful in the cultivation of crops which grow on or near the ground, such as strawberries, melons, etc. Ditch water is used at certain times for all crops on the ranch, but the well water is used at times when muddy ditch water would be detrimental to the crops. The river water, especially in times of flood, contains large quantities of silt, and during dry times the supply may fail altogether. The well water, being free from silt, is used, not only in times of drought, when river water is scarce, but also in flood times, when the use of silty water would injure the crops.

This pumping plant offered favorable opportunity for computing the cost of raising water by means of the gasoline and centrifugal pump. The measurements of the water were made by means of a temporary weir constructed for the purpose, and the quantity of gasoline used is based on an average of many runs. The pump is used ordinarily not more than one hour at a time, but some runs of several hours have been made. Long runs took proportionately less gasoline. Since nearly all the runs in the present case were short ones the computed cost of an acre-foot is greater than it would be if the plant were in continuous operation. The quantity of gasoline consumed in the longest runs, while not accurately measured, was enough less to warrant the assumption that this plant could raise water 21 feet at a cost not exceeding $2.50 per acre-foot.

Cost of pumping water at Nelson & McIlvaine's pumping plant, near Phoenix.

Cost of well (estimated)	$1,000.00
Cost of engine and pump	$1,200.00
Interest on investment at 7 per cent per annum for 6 hours	$0.11
Depreciation at 10 per cent per annum for 6 hours	$0.16
Average amount of water in gallons per minute	900
Hours to pump 1 acre-foot	6
Average amount of gasoline per minute ..... gallons	1.5
Gallons of gasoline to pump 1 acre-foot	9
9 gallons of gasoline at 28 cents	$2.52
Oil, repairs, etc. (estimated)	$0.05

Total cost per acre-foot	$2.88
Lift in feet	21
Average cost per foot in lifting 1 acre-foot	$0.137

PERRY WELL (SEC. 22, T. 1 N., R. 2 E.).

Mr. Wm. H. Perry's well is located north of the river, not far from the Collins well. It is 12 by 16 feet at the top and at present writing is about 20 feet deep; it is not yet complete. Water occurs at a depth of 14 feet and will be raised by centrifugal pump and steam engine having a capacity of about 2,000 gallons per minute.

The well is about three-fourths of a mile from the river, and the elevation of the water in it is influenced by the flow in the river. Three weeks before visiting the well the river was in flood. After the flood had passed, the water in the well gradually rose until at the time of visit the surface was 3 feet higher than it had been three weeks before.

BRADSHAW WELL (SEC. 15, T. 1 N., R. 2 E.).

The well of J. R. and W. W. Bradshaw is 8 by 16 feet and 27 feet deep, and has 8 feet of water. The water is raised by a 6-inch centrifugal pump and 12-horsepower gasoline engine; when in use a stream of 60 inches (675 gallons per minute) is obtained. The plant has not been in use during the present season, 1903, owing to the fact that a satisfactory supply of ditch water was obtained cheaper than water could be pumped.

BROWN WELL (SEC. 13, T. 1 N, R. 2 E.).

J. L. Brown has a dug well, 7 feet in diameter and 19 feet deep, with 6 feet of water. The water, which, until recently, was used for irrigation, was raised by a bucket pump, the power being supplied by 8 horses hitched into a circular arrangement similar to a merry-go-round. A stream of 25 inches (281 gallons per minute) was obtained when the pump was operated. It has not been in use for about two years.

HARRIS WELL (SEC. 6, T. 1 N., R. 2 E.).

J. J. Harris has a 4-inch drilled well 103 feet deep. Water was encountered at a depth of 32 feet, but it contained common salt and alkali in quantities sufficient to render it unfit for use. Again, at a depth of 47 feet, water was encountered so strongly impregnated with salts that it is described as brine. At a depth of 98 feet a gravel bed was encountered, yielding a supply of good water.

Log of J. J. Harris's well.

	Feet.
Soil and clay	32
Sand and gravel, salt water	2
Clay and cement	13
Sand and gravel, brine	3
Clay and gravel	38
Hard cement	10
Gravel and bowlders, water bearing	3

The water from the gravel bed at the bottom of the well rises to within 30 feet of the surface of the ground, 2 feet above the surface of the upper water horizon. The upper saline waters are cased off and the water used is from the lower gravel stratum. The analysis of this water is as follows:

Analysis of water from J. J. Harris's well.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C	268.00
Chlorine in terms of NaCl (common salt)	185.60
Hardness in terms of $CaSO_4$ (sulphate of lime)	34.80
Alkalinity in terms of Na_2CO_3 (black alkali)	None.
Nitrogen in the form of nitrates	2.00
Nitrogen in the form of nitrites	Very faint.
Qualitative:	
Sulphates	Strong.
Magnesia	Strong.
Lime	Very strong.
Bicarbonates	Pronounced.

KELLNER WELL (SEC. 6, T. 1 N., R. 1 E.).

Mr. E. F. Kellner's well, which is situated 12 miles west of Phoenix on the Yuma road, is a 7-inch well 554 feet deep. A light flow of water was obtained at 322 feet, which rose to within 18 feet of the surface. The purpose in sinking the well was to obtain if possible a supply of flowing or artesian water. Owing to accidents in the work the well was never completed and has never been used.

In January, 1904, in taking the temperature of the well it was found to be only 324 feet deep, the lower 230 feet having filled with sand. Water was found at a depth beneath the surface of 32 feet, a lowering of 14 feet since the well was drilled. The temperature at the depth of 324 feet is 82.3° F.

OSTRICH RANCH WELL (SEC. 3, T. 1 N., R. 1 E.).

This is a 4-inch drilled well 170 feet deep with 110 feet of water. Water is raised either by windmill or engine as occasion demands. The pumping is intermittent, but the well is known to yield at least 35 gallons per minute. The full capacity is not known. No satisfactory record of the formation penetrated at this place could be obtained.

Analysis of water from Ostrich ranch well.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C	130.00
Chlorine in terms of NaCl (common salt)	76.00
Hardness in terms of $CaSO_4$ (sulphate of lime)	8.20
Alkalinity in terms of Na_2CO_3 (black alkali)	None.
Qualitative:	
Sulplates	Very strong.
Magnesia	Distinct.
Lime	Strong.
Bicarbonates	Strong.

MOORE WELL (SEC. 11, T. 1 N., R. 1 W.).

The well of Mr. W. G. Moore is situated on the western border of the Agua Fria flood plain. It has been in operation since 1894, and irrigates 250 acres. The well is about 60 feet long and 20 feet wide, and has a maximum depth of 16 feet. The water, which is raised by a 6-inch Byron Jackson centrifugal pump, operated by a traction engine, is said to run at present about 110 inches (1,238 gallons per minute) continuously. More vigorous pumping drains the well. The water is the underflow of the Agua Fria, and the available quantity is directly dependent on the condition of this stream. From 1894 to 1902 a depth of 12 feet supplied a satisfactory quantity of water, but in 1902 the water was low, owing to a long drought, and the well was lowered 4 feet to secure the required amount of water. During the first four months of the present year (1903) the water has risen in the well 3.5 feet.

HEATON WELL (SEC. 15, T. 1 N., R. 1 W.).

Mr. John Heaton's well is 45 feet deep; the lower 33 feet is drilled and has a 6-inch casing. The dug part, 12 feet, is walled and cemented, and serves as a small reservoir. At the bottom is a horizontal suction pipe is attached to the well casing, and supplied with 4 common suction cylinders 5 inches in diameter; from each cylinder a small rod extends to an eccentric revolving shaft at the top of the well. The casing is fitted with a check valve to prevent any return of the water from the well reservoir down the casing pipe when the pumps are stopped. It is thus evident that while in operation the suction cylinders are 12 feet under water, and the 4 iron rods attached to the plungers work through this depth of water with considerable friction. The fourfold plunge pump is operated by an 8-horsepower gasoline engine, in which distillate is used in place of gasoline. The engine has a much greater capacity than the work demands, and runs at a proportionate disadvantage.

A careful computation of the cost of raising water in this manner was made and is given below. The depth from which the water is

lifted while the pump is in operation could not be measured accurately on account of the peculiar construction of the well. It is thought, however, from the behavior of other wells in the vicinity, that the lift does not vary greatly from the figure given below, 28 feet. Since the engine works automatically, there is no account taken of attendance.

Cost of raising water from John Heaton's well.

Cost of well	$100.00
Cost of engine and pump	$400.00
Interest on investment at 7 per cent per annum for 45 hours	$0.18
Depreciation at 10 per cent per annum for 45 hours	$0.26
Capacity of pump in gallons per minute	120
Number of hours to raise 1 acre-foot	45
Gallons of distillate used in a 10-hour run	13
Gallons of distillate used to pump 1 acre-foot	13.5
13.5 gallons of distillate at 25 cents	$3.38
Oil and repairs (estimated)	$0.05
Total cost per acre-foot	$3.87
Lift in feet	28
Average cost per foot in lifting 1 acre-foot of water	$0.138

Analysis of water from John Heaton's well.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C	28.00
Chlorine in terms of NaCl (common salt)	5.20
Hardness in terms of $CaSO_4$ (sulphate of lime)	1.09
Alkalinity in terms of Na_2CO_3 (black alkali)	None.
Qualitative:	
Sulphates	Pronounced.
Magnesia	Pronounced.
Lime	Pronounced.
Bicarbonates	None.

HAYNE WELL (SEC. 1, T. 1 N., R. 1 W.).

L. C. Hayne's well is 11 by 7 feet and 24 feet deep, with 8 feet of water. Water is raised by a small steam engine and a 4-inch centrifugal pump, which is said to supply 50 inches of water (562 gallons per minute).

The well seems to be supplied by seepage from the irrigated area to the east. When irrigation is carried on extensively the water in the well is notably higher.

RICHARDSON DITCH (SEC. 15, T. 1 N., R. 1 W.).

Mr. Richardson has a seepage ditch near the mouth of the Agua Fria. The ditch cuts the water-bearing gravels for about three-fourths of a mile to a maximum depth of 10 feet. The water obtained is estimated at a maximum of 150 inches when the ditch is kept clear. Less than 50 inches were flowing at the time the ditch was visited. The accumulations of sand and algæ cause continuous work in keeping the

ditch clear. Mr. Richardson estimates that the constant work of a man and team is required in order to obtain the best results from the ditch.

Analysis of water from Richardson ditch.

	March 5, 1900.	April 21, 1900.
Quantitative (parts in 100,000):		
Total solids soluble at 110° C	30.00	33.4
Chlorine in terms of NaCl (common salt)	6.00	7.4
Hardness in terms of $CaSO_4$ (sulphate of lime)	None.	None.
Alkalinity in terms of Na_2CO_3 (black alkali)	1.17	1.3
Nitrogen in the form of nitrates	.126	.148
Nitrogen in the form of nitrites	.0032	Faint.
Qualitative:		
Sulphates	Very strong.	Strong.
Magnesia	Strong.	Strong.
Lime	Very strong.	Strong.

COOPER WELL (SEC. 16, T. 1 N., R. 4 E.).

Mr. J. D. Cooper has a small pumping plant north of Tempe. The well is 14 by 20 feet and 22 feet deep, with 4 feet of water. The water is raised by a 4-horsepower gasoline engine and bucket pump, which yields a supply estimated at 20 inches (Pl. VI). The well is in gravels, a few rods from the river bank, and the water comes from the flow of the river, which is here continuous.

THOMAS MURPHY WELL (SEC. 30, T. 2 N., R. 4 E.).

Mr. Thomas Murphy's well is located northeast of Phoenix, west of the Crosscut canal. It is a 6-inch well, 325 feet deep, and is one of the few wells of the region which reach bed rock. The sandstone and conglomerate shown in the log is probably the same as the sedimentary formation which occurs at Camelback Mountain, about 2 miles to the north, and in the buttes just east of the Crosscut canal, and which is described in Chapter II.

Log of Thomas Murphy's well No. 1.

	Feet.
Soil	4
Clay and cement	66
Gravel	3
Cement	5
Gravel, water bearing	37
Clay	27
Gravel	3
Conglomerate	31
Red sandstone	129
Shale	17
Sandstone	3

IRRIGATION BY MEANS OF BUCKETS AT J. D. COOPER'S PUMPING PLANT, NEAR TEMPE.

The conglomerate of this well should not be confused with the water-bearing gravels and bowlders so common in the valley-fill. The valley-fill is here only 140 feet deep; below this depth the material is consolidated red breccia, and can not be expected to yield water so readily as the unconsolidated gravels of the valley-fill.

Analyses have been made from water taken at 4 horizons at this place. The horizons are 78 feet (1), 168 feet (2), 187 feet (3), and 225 feet (4), respectively, below the surface. The water from the upper horizon—that from the 37-foot gravel bed—is strongly charged with sodium carbonate (black alkali), while the waters from the lower horizons are free from the alkali.

Analyses of water from Thomas Murphy's well No. 1.

	No. 1.	No. 2.	No. 3.	No. 4.
Quantitative (parts in 100,000):				
Total solids soluble at 110° C.	380.4	303.2	388.0	325.8
Chlorine in terms of NaCl (common salt)	140.0	136.0	105.0	128.4
Hardness in terms of $CaSO_4$ (sulphate of lime)	10.88	None.	None.	32.1
Alkalinity in terms of Na_2CO_3 (black alkali)	None.	2.70	45.16	None.
Nitrogen in the form of nitrates	2.33	.80	1.43	.66
Nitrogen in the form of nitrites	.40	None.	.0666	.0073
Qualitative:				
Sulphates	Very strong.	Very strong.	Very strong.	Very strong.
Magnesia	Very strong.	Very strong.	Very strong.	Very strong.
Lime	Very strong.	Very strong.	Very strong.	Very strong.

Another deep well is in process of construction by Mr. Thomas Murphy at the northern border of this section. At the present time it is 865 feet deep. Very little water-bearing material was encountered, as is shown in the log. It is worthy of note that the well penetrates red sandstone, presumably the red breccia exposed to the east and to the north, and that beneath the sandstones occurs soft clay. Where the red breccia is exposed at the surface it rests upon granite. This does not seem to be the case in the Murphy well. It is possible that the clay at the bottom is nothing more than soft shale, similar to the shale above, and that the drill worked it into a pliant mass not recognizable from unconsolidated clay. On the other hand it is possible that the clay penetrated by the Murphy-McQueen well at Mesa, and by the 705-foot Chandler well occurs at this place and is penetrated by the Thomas Murphy well.

Log of Thomas Murphy's well No. 2.

	Feet.
Cemented wash	160
Red sandstone	38
Shale and clay containing fragments of granite	225
Alternating layers of shale and sandstone	427
Soft clay	15

Since this is the deepest well in the valley—the Murphy-McQueen well having filled with sand for several hundred feet—a series of temperature observations were made, as follows:

Temperature of Thomas Murphy's well No. 2 at various depths.

Depth.	Temperature.	Time thermometer remained in well.	Remarks.
Feet.	*Degrees.*	*Hours.*	
100.....	74.6+	3	8 feet beneath the water. Temperature probably lowered by surface evaporation.
200.....	79.1+	3	Suspended in water.
300.....	79.8+	16	
400.....	80.0+	7	
500.....	80.6+	17	
600.....	81.1+	2	
700.....	81.9	2	
800.....	82.1	2	
835.....	83.0	20	In mud at bottom.

The observations indicate a moderately regular increase in temperature downward, although that increase is not so rapid as might be expected. No variation of temperature is caused here by circulation of water, as the water-bearing strata are cased off at the present time. Since no work has been done at the well for two months or more the recorded temperatures are evidently the true temperatures for the rock at the various depths.

The temperatures taken at intervals of 100 feet indicate an increase downward of 0.2° F. to 0.9° F. per 100 feet. Reckoned, however, from the basis of the average surface temperature, a very different rate is obtained. The average surface temperature at Phoenix, based on seven years' observation, is 69.3° F. There is, therefore, an increase downward of 14.7° F. in 835 feet, or an average increase of 1° F. for every 57 feet.

All things considered, this series of observations gives the most accurate record of the rate of increase of temperature downward of any observations obtained in this region, but since the well is not in the range of free circulation of Salt River underflow the temperature is not included in the table showing the temperature of that underflow which is given in Chapter IV.

W. J. MURPHY WELL (SEC. 5, T. 2 N., R. 3 E.).

This is a 3-inch drilled well 128 feet deep with 18 feet of water. Water-bearing gravels were encountered at a depth of 110 feet and are at least 18 feet thick.

Log of W. J. Murphy's well.

	Feet.
Alternating sand, clay, and cement	110
Gravel and bowlders, water bearing	18

Analysis of water from W. J. Murphy's well.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C	115.8
Chlorine in terms of NaCl (common salt)	35.6
Hardness in terms of $CaSO_4$ (sulphate of lime)	46.11
Alkalinity in terms of Na_2CO_3 (black alkali)	None.
Qualitative:	
Sulphates	Very strong.
Magnesia	Very strong.
Lime	Very strong.

MESSINGER WELL (SEC. 4, T. 2 N., R. 3 E.).

M. W. Messinger's well is drilled 175 feet deep and cased to the bottom, with no perforations. The water is 52 feet deep, having its surface 123 feet below ground surface. The available quantity of water was tested with a 12-horsepower engine and pump. The yield could not be learned, but when the pump was run at the greatest speed possible the water was lowered only 2 feet.

BEET-SUGAR FACTORY WELL (SEC. 8, T. 2 N., R. 2 E.).

A 6-inch well has been drilled at the beet-sugar factory now in process of construction near Glendale. The well is 117 feet deep and is designed only to furnish water for the construction work of the factory. The water is drawn from the gravels at the bottom of the well. It is under very little pressure, as it stands about 100 feet below the surface.

Log of well at beet-sugar factory, Glendale.

	Feet.
Soil	8
Sand and gravel	2
Clay	7
Cemented gravel	2
Clay	29
Cement	8
Cemented bowlders	16
Cement	14
Clay	19
Sand and gravel, water bearing	12

Analyses of water from well at beet-sugar factory, Glendale.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C	54.60
Chlorine in the terms of NaCl (common salt)	15.50
Hardness in the terms of $CaSO_4$ (sulphate of lime)	None.
Alkalinity in the terms of Na_2CO_3 (black alkali)	1.99
Nitrogen in the form of nitrates	1.24
Nitrogen in the form of nitrites	.08

Qualitative:

Sulphates	Pronounced.
Magnesia	Faint.
Lime	Pronounced.
Bicarbonates	Strong.

BARTLETT WELL (SEC. 4, T. 2 N., R. 2 E.).

S. C. Bartlett's well, one of the first to be drilled in the region, was completed in 1892. It was 311 feet deep, but was cased with 4-inch pipe to a depth of only 70 feet. No log of the well was preserved, but Mr. A. J. Straw, who was managing the Bartlett ranch at the time the well was put down, stated that the first water struck was at the depth of 120 feet. A second water-bearing stratum was penetrated at a depth of about 185 feet, and a third at the bottom of the well—311 feet.

This well has been of great interest in the community on account of certain indications which lead to the supposition that water is to be found under sufficient pressure to make flowing wells. Mr. Straw, who is himself an experienced well driller, and has put down a large number of the wells near Phoenix, said that at a depth of 311 feet the drill struck a very hard layer, on which the drilling machinery employed was not strong enough to have much effect. After pounding for about two hours the water is said to have suddenly spurted from the well, rising about 7 feet above the top of the casing. The upward rush of the water lifted the drill and operations were stopped. The water flowed from the well for a few moments, then gradually ceased. The next morning the drill was started again and the water is said to have again spurted from the top of the pipe as before, and operations were discontinued, the drilling machinery being inadequate to cope with the difficulty.

Water enough was obtained to supply all needs at the time and nothing further has been done to the well. Since the casing reaches only to a depth of 70 feet, the lower portion of the well soon filled and the water is now derived presumably from the upper or 120-foot horizon.

ALKIRE WELLS (SEC. 21, T. 2 N., R. 2 E.).

Frank Alkire has two drilled wells in this locality. The last one was completed in 1903; it is a 6-inch well 96 feet deep. No water worthy of mention was encountered until the well reached a depth of 96 feet, when a gravel bed was entered, which yields all the water desired. This water was confined by a hard layer of cement.

Log of Frank Alkire's well near Phoenix.

	Feet.
Soil	22
Sand and gravel, dry	6
Clay, sand, and cement	27
Gravel, a little water	10
Cement	1
Bowlders, water bearing	?

Analysis of water from Frank Alkire's well, near Phoenix.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C	41.1
Chlorine in terms of NaCl (common salt)	10.0
Hardness in terms of $CaSO_4$ (sulphate of lime)	Strong.
Alkalinity in terms of Na_2CO_3 (black alkali)	None.
Nitrogen in the form of nitrates	.0004
Nitrogen in the form of nitrites	1.5

SILVA WELL (SEC. 15, T. 2 N., R. 2 E.).

Mr. Alexander Silva's well is dug 100 feet and drilled 35 feet. The water stands 95 feet below the surface. Some water was found in black sand at a depth of 103 feet, but no satisfactory supply was obtained until gravel was reached at a depth of 110 feet. The water from this gravel bed flows continually from the top of the pipe into the open or dug part of the well and leaks back again in the stratum of sand above.

Log of Alexander Silva's well near Phoenix, Ariz.

	Feet.
Soil	12
Sand and gravel	6
Alternating layers of cement, clay, and sand	72
Quicksand	6
Hard cement	7
Black sand	4
Clay	9
Sand, gravel, and bowlders, water bearing	16

MILLER WELL (SEC. 33, T. 2 N., R. 2 E.).

Edward Miller has a 4-inch drilled well 78 feet deep, with 24 feet of water. A stream of salt water was encountered at a depth of 50 feet. Beneath the salt water a stratum of cement occurs, beneath which is a sand yielding a satisfactory supply of good water. This water is under slight pressure and rose a few feet when struck.

Log of Edward Miller's well near Phoenix, Ariz.

	Feet.
Sandy soil	16
Bowlders, dry	4
Cement, sand, and clay	30
Gravel, salty water	3
Cement	?
Sand, water bearing	?

HOUGH WELL (SEC. 6, T. 2 N., R. 2 E.).

Mr. Samuel Hough has a 6-inch drilled well 105 feet deep, with 15 feet of water. For 95 feet the material is sand, clay, and gravel, more or less cemented; for the lower 10 feet it is uncemented gravel. The material is sufficiently firm to stand without casing, and the well is cased only a few feet from the top. It has been in use since 1899.

A. H. SMITH WELL (SEC. 21, T. 2 N., R. 2 E.).

A. H. Smith's well was dug 96 feet deep and had originally 13 feet of water, probably derived from the gravel bed reached by other wells of the vicinity, though this can not be definitely stated. At a depth of 96 feet the well was in a hard cement which required blasting; after the blast the workman descended but found the water 13 feet deep in the well, and nothing further has ever been done. The water is used only for domestic purposes, but the supply seems to be abundant.

Analysis of water from A. H. Smith's well.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C	130.5
Chlorine in the terms of NaCl (common salt)	40.0
Hardness in the terms of $CaSO_4$ (sulphate of lime)	Strong.
Alkalinity in the terms of Na_2CO_3 (black alkali)	None.
Nitrogen in the form of nitrates	10.0
Nitrogen in the form of nitrites	.012

GLENDALE TOWN WELL (SEC. 8, T. 2 N., R. 2 E.).

This is a 6-inch drilled well 112 feet deep, and contains 12 feet of water. It was put down in 1894 and has yielded a satisfactory supply of water ever since that time.

Analysis of water from the Glendale town well, Glendale, Ariz.

Quantitative (parts in 100,000):	
Total soluble solids at 110° C	79.2
Chlorine in terms of NaCl (common salt)	39.0
Hardness in terms of $CaSO_4$ (sulphate of lime)	Strong.
Alkalinity in terms of Na_2CO_3 (black alkali)	None.
Nitrogen in the form of nitrates	None.
Nitrogen in the form of nitrites	.0003

HAMILTON WELL (SEC. 5, T. 2 N., R. 2 E.).

Mr. H. W. Hamilton has a 6-inch drilled well 120 feet deep, with 7 feet of water. Water-bearing gravels were encountered at a depth of 119 feet.

Analysis of water from H. W. Hamilton's well.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C	115.80
Chlorine in terms of NaCl (common salt)	35.60
Hardness in terms of $CaSO_4$ (sulphate of lime)	46.11
Alkalinity in terms of Na_2CO_3 (black alkali)	None.
Qualitative:	
Sulphates	Very strong.
Magnesia	Very strong.
Lime	Very strong.
Bicarbonates	No trace.

J. P. ORME WELL (SEC. 25, T. 2 N., R. 1 E.).

Mr. J. P. Orme's well is dug 74 feet deep. At a depth of 44 feet gravels were encountered which yielded a little water, but the supply was not satisfactory and the well was deepened. At a depth of 72 feet a loose gravel bed was found which yielded a large supply, the water rising 26 feet and remaining near that level since the well was dug in 1885. The well is now filled to some extent so that the water does not actually measure 26 feet. The water from the lower gravels is said to be much better in quality than that which comes from higher horizons.

Log of J. P. Orme's well, near Phoenix.

	Feet.
Soil	18
Loose gravel and sand	12
Cement	14
Loose gravel and sand, little water	15
Cement	13
Gravel, water bearing	2

L. B. ORME WELL (SEC. 35, T. 2 N., R. 1 E.).

L. B. Orme has a 4-inch drilled well 102 feet deep. The material to a depth of 76 feet is clay, sand, and cement, yielding no satisfactory water supply. At 76 feet a gravel bed was encountered from which the water rose 14 feet—to within 62 feet of the surface.

Log of L. B. Orme's well, near Phoenix.

	Feet.
Soil	6
Sand and gravel	6
Soil	10
Alternating layers of cement, clay, and sand	54
Gravel and bowlders, water bearing	26

BURROWS WELL (SEC. 35, T. 2 N., R. 1 W.).

Dr. C. Burrows's well, which is 10 feet square and 25 feet deep, is a seepage well in the sands and gravels of the Agua Fria. It was in use from 1896 to 1900. Water was raised by steam power and a centrifugal pump, which furnished a continuous stream of 150 inches (1,680 gallons per minute). No use has been made of the well since 1900.

WIEDER WELL (SEC. 32, T. 3 N., R. 3 E.).

J. A. Wieder's well is drilled 146 feet deep. Near the bottom is a sand stratum that yields the water, which is 17 feet deep and of good supply. The windmill with which the well is supplied has not been able to exhaust the supply even in the strongest winds. The well is not cased, and yet in the six years since it was drilled only 1 foot of sand has accumulated at the bottom, the material through which it is drilled being almost entirely composed of the coarse angular wash from the hills. No waterworn gravels were encountered.

Analysis of water from J. A. Wieder's well.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C	76.1
Chlorine in terms of NaCl (common salt)	31.5
Hardness in terms of $CaSO_4$ (sulphate of lime)	Strong.
Alkalinity in terms of Na_2CO_3 (black alkali)	None.
Nitrogen in the form of nitrates	.70
Nitrogen in the form of nitrites	.0078

FOWLER WELL (SEC. 33, T. 3 N., R. 2 E.).

Mr. B. A. Fowler has a 6-inch drilled well 133 feet deep with 8 feet of water. The well was drilled in 1899. No accurate log of the well was kept, but the presumption is that the water comes from a depth of 133 feet.

Analysis of water from B. A. Fowler's well.

Quantitative (parts in 100,000):	
Total solids soluble at 110° C	80.9
Chlorine in terms of NaCl (common salt)	13.2
Hardness in terms of $CaSO_4$ (sulphate of lime)	36.5
Alkalinity in terms of Na_2CO_3 (black alkali)	None.

COLE WELL (SEC. 31, T. 3 N., R. 2 E.).

This well is dug 125 feet deep. The material is alternating layers of sand, clay, and cement for 123 feet, when a water-bearing sand is encountered. Two feet deeper a strong flow was struck from which the water rose 19 feet, where it has remained practically constant since 1896, when the well was dug.

Log of N. O. Cole's well, near Phoenix.

	Feet.
Alternating layers of sand, clay, and cement	123
Sand and gravel, water bearing	2

TABULATION OF WELLS FOR PHOENIX REGION.

Many wells in the Phoenix region were visited in addition to those described. In most cases nothing was found worthy of special description, and the measurements were placed directly on the map for construction of the water table. In other cases meager information was obtained, as indicated in following table:

Well records of the Phoenix region.

[Data gathered in part by various members of R. W. Hawley's survey party.]

Number.	Owner.	Post-office.	Location.			Completed.	How put down.	Depth of well.	Depth to water.	Did water rise when struck?	Elevation of surface.	Elevation of water.
			Township.	Range.	Section.							
								Feet.	*Feet.*		*Feet.*	*Feet.*
	Phoenix Water Co. (2 shallow and 3 drilled wells)	Phoenix	1 N.	3 E.	4	1902	Drilled	208	40	No	1,092	1,052
1	G. W. Barnard	Tempe	1 N.	3 E.	8	1896	Dug	28	21	No	1,143	1,122
	Arizona Laundry Co	Phoenix	1 N.	3 E.	8	1900	do	35	32	No	1,087	1,055
	City Park	do	1 N.	3 E.	9	1902	do	42	31	No	1,092	1,061
	Lewis Wetzler	do	1 N.	3 E.	11	1900	do	40	25	No	1,113	1,088
	Frank Wagner	do	1 N.	3 E.	16	1902	do	35	27	No	1,091	1,064
	L. Kunz	do	1 N.	3 E.	18	1899	do	24	18	No	1,063	1,045
	A. C. Bartlett	do	1 N.	3 E.	27	1901	do	42	34	No	1,103	1,061
	William Christy	do	1 N.	2 E.	1	1902	Drilled	45	37	Yes	.....	.....
	J. J. Harris	do	1 N.	2 E.	6	1901	do	103	30	Yes	1,046	1,016
	I. L. Brown	do	1 N.	2 E.	13	1901	do	19	13	.....	.....	.....
	Nelson & McIlwaine	do	1 N.	2 E.	15	.....	Dug	20	14	No	1,048	1,034
	J. R. Bradshaw	do	1 N.	2 E.	15	1900	do	27	19	No	.....	.....
	George U. Collins	do	1 N.	2 E.	15	1901	do	29	14	No	1,043	1,029
	William H. Perry	do	1 N.	2 E.	22	1903	do	.....	14	No	1,038	1,024
	N. P. McCallum	do	1 N.	2 E.	24	1903	Drilled	.....	14	No	1,051	1,037
24	W. W. Messinger	do	2 N.	3 E.	4	1899	do	175	123	Yes	1,207	1,184
23	F. L. Howard	do	2 N.	3 E.	4	1900	do	175	127	Yes	1,198	1,071
25	Thos. S. Wallin	do	2 N.	3 E.	5	1890	Dug	104	100	No	1,179	1,079
26	Mrs. A. Allen	do	2 N.	3 E.	5	1898	Drilled	.....	.....	No	1,194	.....
27	W. J. Murphy	do	2 N.	3 E.	5	1897	do	130	110	.....	1,197	1,087
19	—— Barney	Glendale	2 N.	3 E.	6	1897	do	96	95	.....	.....	.....
29	Harry Thompson	Phoenix	2 N.	3 E.	8	1899	do	104	94	Yes	1,175	1,081
28	J. M. Jamison	do	2 N.	3 E.	8	1897	Dug	125	94	.....	1,173	1,079

Well records of the Phoenix region—Continued.

Number.	Owner.	Post-office.	Location.			Completed.	How put down.	Depth of well.	Depth to water.	Did water rise when struck?	Elevation of surface.	Elevation of water.
			Township.	Range.	Section.							
								Feet.	*Feet.*		*Feet.*	*Feet.*
20	G. F. Houghton	Phoenix	2 N.	3 E.	15	1901	Drilled	98	78	Yes	1,159	1,081
21	Mrs. K. Young	do	2 N.	3 E.	15	1902	Dug	100	95	Yes	1,174	1,079
22	do	do	2 N.	3 E.	15		Drilled	101	88	No	1,159	1,071
	Indian School	do	2 N.	3 E.	20	1903	do	198	36		1,115	1,079
19	Smith & Raney	do	2 N.	3 E.	22	1898	do	90	70	No	1,153	1,083
16	H. H. Munger	do	2 N.	3 E.	23	1899	Dug	83	81	Yes	1,177	1,096
17	C. W. Perkins	do	2 N.	3 E.	23	1901	Drilled	154	82	Yes	1,184	1,102
18	W. D. Bell	do	2 N.	3 E.	23	1902	do				1,171	
8	A. M. Fredrick	do	2 N.	3 E.	27	1883	Dug	56	52	Yes	1,120	1,068
9	B. R. Ellison	do	2 N.	3 E.	27	1901	do	52	50	No	1,123	1,073
7	R. R. Hedgepath	do	2 N.	3 E.	27	1901	do	45	43	Yes	1,117	1,074
13	Elva Hasford	do	2 N.	3 E.	27		do	53	52		1,136	1,084
14	Lee Barnett	do	2 N.	3 E.	27	1901	Drilled	54	37	No	1,133	1,096
15	—— Anderson	do	2 N.	3 E.	27		Dug	58	57	No	1,129	1,071
11	—— McFall	do	2 N.	3 E.	27	1883	do	47	43	No	1,128	1,086
10	J. E. Tounehill	do	2 N.	3 E.	28	1883	do	50	44	No	1,123	1,079
49	L. Perkins	do	2 N.	3 E.	29	1887	do	40	36	No	1,096	1,060
56	Dr. Stone	do	2 N.	3 E.	29	1902	do	53	35	No	1,098	1,063
44	R. B. Quinn	do	2 N.	3 E.	30	1893	Drilled	80	40	No	1,096	1,056
46	—— Warren	do	2 N.	3 E.	30	1888	do	80	40	No	1,105	1,065
48	S. Evans	do	2 N.	3 E.	30	1893	Dug	42	38	No	1,101	1,063
50	C. M. Baum	do	2 N.	3 E.	30	1886	do	43	37	No	1,096	1,059
33	R. H. Green	do	2 N.	3 E.	30	1893	do	50	45	No	1,112	1,067
34	W. T. Cage	do	2 N.	3 E.	30	1902	do	35	33	No	1,112	1,070
36	H. C. Buford	do	2 N.	3 E.	30	1893	do	33	32	No	1,107	1,075
38	C. E. Kirk	do	2 N.	3 E.	30	1900	do	45	41	No	1,105	1,064

51	L. H. Chamler	do	2 N.	3 E.	32	1902	do	37	29	No	1,089	1,060	
52	G. F. Kemper	do	2 N.	3 E.	32	1889	do	46	26	No	1,088	1,062	
53	J. R. Evans	do	2 N.	3 E.	32	1902	do	35	31	No	1,088	1,057	
55	J. P. Orme	do	2 N.	3 E.	32	1884	do	50	30	No	1,089	1,059	
57	W. E. Thomas	do	2 N.	3 E.	32	1890	do	51	30	No	1,096	1,068	
	A. C. Bartlett	do	2 N.	3 E.	32	1900	do	44	28	No	1,087	959	
	D. B. Heard	do	2 N.	3 E.	32	1901	Drilled	42	26	No	1,092	1,066	
2	Thos. Armstrong	do	2 N.	3 E.	33	1902	Dug	44	40	No	1,110	1,070	
3	John Horrineg	do	2 N.	3 E.	34	1886	do	57	53	No	1,128	1,075	
4	Anna Anderson	do	2 N.	3 E.	35	1894	do	50	46	No	1,128	1,082	
5	M. F. White	do	2 N.	3 E.	35	1888	do	54	52	No	1,124	1,072	
18	M. B. Laymon	Glendale	2 N.	2 E.	1	1896	Drilled	104	86				
19	E. Fiscall	do	2 N.	2 E.	1	1897	do	96	89	Yes	1,210	1,119	
	S. C. Bartlett	do	2 N.	2 E.	4	1892	do	311		Yes	1,180		
	H. W. Hamilton	do	2 N.	2 E.	5	1899	do	120	113		1,176	1,063	
13	John Toney	do	2 N.	2 E.	5		do	108	92	Yes	1,156	1,064	
	Saml. Haugh	do	2 N.	2 E.	6	1899	do	105	90	Yes	1,120	1,030	
	E. T. Hawkins	do	2 N.	2 E.	6	1899	do	112	91		1,155	1,064	
7	Beet-sugar factory	do	2 N.	2 E.	8	1903	do	117	105	Yes	1,163	1,058	
	Alexander Silva	Phoenix	2 N.	2 E.	15	1899	Dug	135	95	Yes	1,157	1,062	
	A. H. Smith	Alhambra	2 N.	2 E.	21	1897	do	91	82	Yes	1,138	1,056	
	Frank Alkire	Phoenix	2 N.	2 E.	21	1903	Drilled	96			1,135		
	Elliot Evans	do	2 N.	2 E.	25	1902	Dug	68	64	No	1,109	1,045	
	—— Corness	do	2 N.	2 E.	29	1902	do	60	58	No	1,086	1,028	
	J. M. Pike	do	2 N.	2 E.	32	1886	do	64	52	Yes	1,079	1,027	
	Edward Miller	do	2 N.	2 E.	33	1899	Drilled	78	54	Yes	1,092	1,038	
	Jacob Miller	do	2 N.	2 E.	33	1900	do	133	60	Yes	1,086	1,020	
	Chris Miller	do	2 N.	2 E.	34		do	72	47	Yes	1,093	1,046	
11	W. Pope	do	2 N.	E.	9	1900	Dug	40	38	Yes	1,074	1,036	
13	—— Young	do	2 N.	E.	9	1890	do	40	38	Yes	1,035	997	
4	W. H. Brown	Alhambra	2 N.	E.	14	1898	do	80	68	Yes	1,086	1,018	
8	—— Pendergrast	Phoenix	2 N.	1 E.	16	1900	do	50	47	Yes	1,057	1,010	
16	—— Simpson	do	2 N.	1 E.	21	1899	do	63	59	Yes	1,047	988	
17	H. M. Wilburn	do	2 N.	1 E.	22	1903	Drilled	71	56	Yes	1,064	1,008	
7	J. D. Hawkins	Alhambra	2 N.	1 E.	22	1893	Dug	60	56	Yes	1,069	1,013	

Well records of the Phoenix region—Continued.

Number.	Owner.	Post-office.	Location.			Completed.	How put down.	Depth of well.	Depth to water.	Did water rise when struck?	Elevation of surface.	Elevation of water.
			Township.	Range.	Section.							
								Feet.	*Feet.*		*Feet.*	*Feet.*
5	M. S. Rogers	Phoenix	2 N.	1 E.	22	1888	Dug	70	58	Yes	1,074	1,016
3	R. O. Green	do	2 N.	1 E.	23	1890	do	76	38	Yes	1,089	1,051
18	W. H. Wilke	Alhambra	2 N.	1 E.	23	1888	do	68	60	Yes	1,077	1,017
1	—— Green	Phoenix	2 N.	1 E.	25	1896	do	70	67	Yes	1,087	1,020
	Mrs. Wilke	do	2 N.	1 E.	25	1896	do	73	57	Yes	1,091	1,034
	J. P. Orme	do	2 N.	1 E.	25	1885	do	74	58	Yes	1,075	1,017
	J. J. Meyer	do	2 N.	1 E.	26		do	63	59	No	1,065	1,006
	L. B. Orme	do	2 N.	1 E.	35	1900	Drilled	102	62	Yes	1,060	998
	J. A. Wieder	do	3 N.	3 E.	32	1897	do	146	139	No	1,214	1,075
	W. H. Bartlett	Glendale	3 N.	2 E.	30	1891	Dug	132	116		1,181	1,064
	N. O. Cole	do	3 N.	2 E.	31	1896	do	125	106	Yes	1,165	1,059
	B. A. Fowler	Phoenix	3 N.	2 E.	33	1899	Drilled	133	125	No	1,192	1,067
18	—— Woolsey	Peoria	3 N.	1 E.	14	1899	do	93	85	Yes	1,157	1,072
	A. J. Straw	do	3 N.	1 E.	25	1898	do	100	86	Yes	1,157	1,071
1	E. D. Clark	do	3 N.	1 E.	26	1889	Dug	90	86	Yes	1,141	1,055
2	R. H. Tuckey	do	3 N.	1 E.	26	1903	Drilled	93	76	No	1,130	1,054
14	R. W. Wagner	Glendale	3 N.	1 E.	36	1895	Dug	97	82	Yes	1,137	1,055

CHAPTER II.

GEOLOGY.

The formations within the area covered by the accompanying geologic map (Pl. VII) are limited in number, owing to the fact that the only map of the region available for use in showing the areal distribution of the geologic formations, was constructed primarily as a map of irrigable lands. In order to obtain a correct conception of the geologic relations of the valley, something of the surrounding hills must be known. For this reason a brief description of the formations occurring near Salt River Valley is included with those represented on the map.

PRE-CAMBRIAN ROCKS.

A small area of the Archean complex is included in the region shown on the map north of Tempe and in Camelback Mountain. The rock is mainly granite and gneiss, intersected in numerous places by dikes, most of which are highly decomposed. Outside the valley the granites are extensively exposed in the surrounding hills. In the Salt River Mountains, south of Phoenix, a fine-grained biotite-granite occurs, which is being used successfully as an ornamental stone. Granite occurs in large masses in the Sacaton Mountains, southeast of Salt River Valley and in the mountains to the east and the north. The granites, particularly to the east, are very coarse grained, the feldspars often attaining a diameter of 2 inches. The rock disintegrates in the arid climate of Arizona to a coarse-grained arkose, commonly known in this region as granitic wash.

Three samples of rock, so chosen that they are representative of the granites in and about Salt River Valley, have been described by J. E. Spurr, of the United States Geological Survey, as follows:

No. 1. Mountains south of Salt River and east of Mesa, Ariz., coarse, siliceous biotite-granite. Structure—hypidiomorphic, granular, with a tendency to idiomorphism, suggesting at times a micro-pegmatitic structure. This rock contains abundant quartz; orthoclase containing a great deal of sericite, probably a decomposition product; microline; and an undetermined finely striated feldspar, which is very likely albite. There is also frequent biotite, almost entirely altered to chlorite and epidote, with abundant titanite, and considerable original magnetite. The whole rock shows the effects of weathering markedly, but is not profoundly decomposed.

No. 2. Same locality as No. 1. Siliceous granite, similar to No. 1. Structure—coarse, hypidiomorphic; contains orthoclase, including much sericite, probably sec-

ondary; quartz contemporaneous in general with the feldspar, but largely segregated in veinlike bodies; abundant epidote and chlorite. Titanite is relatively abundant. The rock shows the effect of weathering to a considerable extent.

No. 3. From head-gate of Consolidated canal. Siliceous biotite-granite. Structure—irregular, coarse to fine, hypidiomorphic, granular, in part poikilitic; contains orthoclase, partly kaolinized; microline slightly decomposed to sericite and kaolinic decomposition products, and a striated feldspar whose optical properties show it to be very siliceous, probably anorthoclase. The abundant biotite is fairly fresh; quartz is present in large quantity; fine muscovite occurring in the orthoclase in flakes may be secondary, but is probably original; original magnetite is present; titanite is in large and abundant crystals.

This rock, although a different facies from Nos. 1 and 2, is of the same petrographic character, and all can very easily belong to a single rock mass or intrusion. The condition of this rock is fairly fresh.

In addition to the granites there are extensive series of gneisses in the hills surrounding the valley. The granites pass into the gneisses by imperceptible gradations. Rocks occur in which the feldspars are but slightly deformed, while others reveal a highly gneissoid structure. Bands of gneiss were noted in several places in the midst of granites which show little or no gneissoid structure, probably where movement has occurred along lines of least resistance, while the more resistant masses remained unchanged.

In the Phoenix Mountains, immediately north of the city of Phoenix, occurs an extensive series of metamorphosed sediments, many thousands of feet in thickness (Pl. VIII, *A* and *B*). The layers rest in a nearly vertical position. The quartzite which makes up a large proportion of this series has probably furnished many of the quartzite bowlders of the valley fill, which are described later.

In the Tonto basin east of Salt River Valley an extensive series of quartzites, argillites, etc., occur, which, although they are pre-Cambrian are much less disturbed and less altered than the sedimentaries of Phoenix Mountains (Pl. IX). The pre-Cambrian series of Tonto basin is probably the Apache group of Ransome.[a] Dr. Charles D. Walcott refers this formation to the Algonkian. He writes regarding the relations at the Tonto dam site:

> The Carboniferous limestones rest directly and unconformably upon the quartzites and argillites of the Algonkian.[b]

The formation is composed throughout of extremely resistant rock, forming an escarpment in which the strata are nearly horizontal, as in the Sierra Ancha (Pl. IX, *B*), overlooking the Tonto basin, or forming a ridge where the strata are tilted, as in the ridge through which Salt River has cut its gorge at the Tonto dam site (Pl. IX, *A*, and fig. 11).

[a] Ransome, F. L., Geology of the Globe copper district, Arizona: Prof. Paper U. S. Geol. Survey No. 12, 1903, pp. 28–39. Geology of Globe quadrangle: Geologic Atlas U. S., folio 111, U. S. Geol. Survey, 1904.

[b] Personal communication.

A. TILTED PRE-CAMBRIAN QUARTZITES AND ARGILLITES IN THE PHOENIX MOUNTAINS.

B. PHOENIX PEAK, NORTH OF PHOENIX.

A. SALT RIVER DAM SITE, LOOKING UPSTREAM INTO TONTO BASIN.

The rock is Algonkian quartzites and argillites dipping upstream. Photograph by Walter Lubkin.

B. SIDE CANYON IN TONTO BASIN.

Showing the nature of the quartzites and argillites of the Algonkian strata of the Sierra Ancha.

The thickness of this formation as exposed in this gorge is about 1,800 feet. In the Sierra Ancha the same formation is seen and seems to be much thicker. It is extensively exposed along Salt

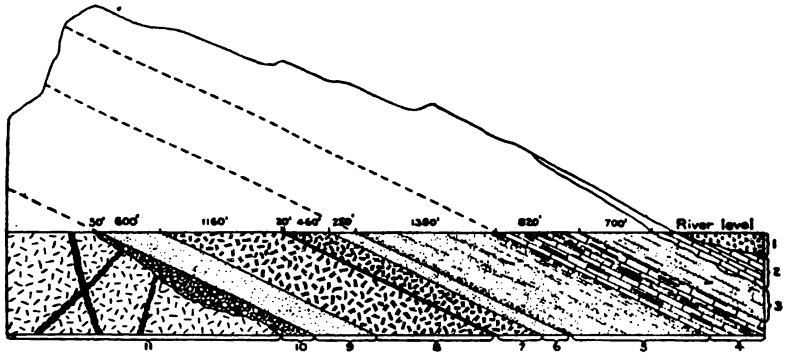


FIG. 11.—Section through Salt River gorge at the Tonto dam site.

River, east of Tonto basin, and has probably furnished the greater portion of the gravel and bowlders of the valley fill of Salt River Valley.

CARBONIFEROUS ROCKS.

The formation next younger than the Apache, so far as known in the vicinity of Salt River Valley, is the lower Carboniferous. Fossiliferous limestones rest upon the Apache group in the Tonto basin, and have yielded the following fossil forms:

Fossils from limestone at Tonto basin dam site.

Zaphrentis sp.
Menophyllum excavatum.
Syringopora surcularia.
S. aculeata.
Leptopora typa.
Rhipidomella sp.
Schuchertella inæqualis.
Productus lævicosta.
Spirifer centronatus.
Spirifer sp.
Camarotœchia metallica.
Platyceras sp.
Bellerophon sp.
Fish tooth.

Fossils from limestones near Tonto basin dam site.

Zaphrentis sp.
Menophyllum excavatum.
Cyathophyllum sp.
Syringopora surcularia.
Leptopora typa.
Rhipidomella sp.
Schuchertella inæqualis.
Spirifer centronatus.

Fossils from limestone at Windy Hill, Tonto basin.

Menophyllum excavatum.
Cyathophyllum sp.
Syringopora aculeata.
Leptopora typa.
Crinoidal fragments.
Spirifer centronatus.
Seminula humilis?

These fossils were identified by George H. Girty, paleontologist of the United States Geological Survey, who refers the formation to the Lower Carboniferous. The fossils are identical with those found in the Redwall limestone of the Grand Canyon section. In writing of the fauna, Mr. Girty says:

> The opinion is expressed with considerable confidence that the faunas represent the earlier half of Mississippian time. The fauna is that which has a wide range throughout the West, having been found in almost every State east of the Sierra Nevadas. It characterizes the Madison limestones of Wyoming and Montana, the Ouray limestones of Colorado (in its upper portion), the lower part of the Wasatch limestones of Utah, etc. The fauna resembles that of the Kinderhook and Osage divisions of the Mississippi Valley section.

TERTIARY (?) DEPOSITS.

SEDIMENTARY ROCKS.

It is not certainly known that any Mesozoic strata are represented in or near Salt River Valley. Near Tempe occur several isolated exposures of red sandstones, conglomerates, and breccias, of which a thickness of about 200 feet is exposed at Tempe Butte. The base is a massive sandstone, used in the valley for building purposes. The sands become more and more argillaceous toward the top, where red shale underlies the lava capping the butte. These strata dip 55° to the southeast and strike N. 60° E.

North of the river at Tempe occurs a series of red sandstones passing downward through a coarse arkose to a granitic breccia at the base. The formation is apparently a continuation of the sandstones of Tempe Butte, although it dips southwest 65° (strike N. 40° W.), nearly at right angles to the direction of dip at the Butte. This formation apparently extends little more than a mile north of the river, although this can not be confidently stated on account of the fragmental débris which covers the greater part of the surface. A well about 1.5 miles northwest of Tempe is in sandstone to the depth of about 200 feet, while a well 2.5 miles northwest of Tempe is entirely in granite to the depth of 110 feet. The attitude of the sandstones both north and south of the river is best explained by faulting, but the fault planes are entirely obscured by surface débris. The sandstone is shown in Pl. XII. Nothing has been found to indicate its age.

In the buttes north of Tempe (Pl. XI, *B*) and on the western slope of Camelback Mountain (Pl. XI, *A*) occurs a formation composed of arkose sandstone, breccia, and conglomerate. It is coarse and massive and indicates only the roughest kind of bedding. It rests upon an uneven surface of granite and the base is composed wholly of fragmental granite. Higher in the series other constituents enter. Quartz, quartzite, jasper, and a number of species of igneous rocks were noted. In places the pebbles are well rounded, forming a conglomerate,

A. CAMELBACK MOUNTAIN, NEAR PHOENIX.

Showing breccia at the left, resting on the flank of a granite mountain

B. BUTTES NORTH OF TEMPE.

but on the whole the material is sharply angular. The base is not well defined. The massive granite gives place to a granitic agglomerate scarcely separable from the unbroken granite beneath, and this agglomerate passes upward into conglomerate, breccia, and arkose sands according to locality. In Pl. XI, *A*, granite is shown at the right, and massive granoclastics at the left, passing upward to stratified breccia.

The sandstone and breccia of the Tempe region are similar in being red, arkose, and devoid of fossil forms. It is possible that they form a single series passing from the granoclastic mass at the base through the breccias and sandstones to the shale at the top. They are not found in actual contact, and are apparently unconformable. The breccia seems to lie across the upturned sandstone, and upon the granite beyond. It is probable that the sandstone, together with the granite against which it rests, was upturned and deeply eroded previous to the deposition of the breccia.

Owing, no doubt, to their resemblance in color and texture to the Triassic sandstones occurring elsewhere, these two formations have been referred to the Trias. Professor Blake[a] refers to them briefly as follows:

> Formations of the Mesozoic are not absent in southern Arizona. The massive red sandstones north of Phoenix, of Tempe, and of Mesa in Salt River Valley are referred to the Trias.

In fig. 17 I have attempted to show in a general way the relation of Salt River Valley to the great continental plateau. It is probable that the sedimentary formations (pre-Cambrian and Carboniferous) forming the escarpment, and the mountain ridge at the Tonto dam site, formerly extended over Salt River Valley, and were carried away by erosion after the elevation of the plateau. In that case a formation resting in contact with the pre-Cambrian formations of the valley can scarcely be of Triassic age. The well-known Triassic of Arizona is found on the top of the plateau, being thus elevated when the plateau was raised. If the supposition is correct that the low-lying area beyond the edge of the plateau, of which Salt River Valley is a part, is in large measure due to degradation subsequent to the elevation of the plateau, any formation resting on that degraded surface must be later than the period of degradation. The elevation of the plateau began, so far as known, at the end of the Cretaceous period. A long period of erosion must have elapsed subsequent to the elevation of the plateau before the sandstone and breccia were laid down. For these reasons the breccia is thought to be not older than late Tertiary, and may indeed be equivalent to the Gila conglomerate, which Gilbert regards as early Quaternary. Beyond the suggestion that the sand-

[a] Blake, William P., Some salient features in the geology of Arizona with evidences of shallow seas in Paleozoic times: Am. Geol., March, 1901, p. 166.

TEMPE BUTTE, SHOWING TILTED SANDSTONE AT THE RIGHT, OVERLAIN BY ANDESITE.

stone and breccia may be phases of a single accumulation, the age of the sandstone must remain an open question.

Judging from the character of the breccia and its relation to older rocks, there is little doubt that it is due to upland accumulations. The size of some of the granite blocks—many of them several feet in diameter—indicates that action was violent and granite highlands not far distant when the breccia was formed. In general character the breccia closely resembles the Gila conglomerate of Gilbert. On the other hand it is evident from the remnants left in the valley that this breccia formerly had a wide areal distribution and that the greater part of it has been carried away. All things considered it seems preferable to refer the formations exposed at Tempe tentatively to late Tertiary.

TERTIARY LAVAS.

Eruptive rocks occur within Salt River Valley in Bell Butte (see Pl. XIII, *A*), Tempe Butte, and a line of small buttes north of Tempe. The rock from Bell Butte is described by J. E. Spurr as follows:

> Butte southwest of Tempe, Ariz.: Hornblende-pyroxene-andesite, fine grained. Structure—fine porphyritic. Phenocrysts of pale-brown basaltic hornblende, altered along the edges to calcite and iron; pseudomorphs of calcite and iron oxide after pyroxene; and turbid feldspars which are altered chiefly to calcite, indicating their belonging to the soda-lime group. The groundmass is glassy, in part microlithic, and shows altered feldspars, etc. This rock is highly altered.

In the hills surrounding the valley occur extensive masses of eruptive rock, consisting of rhyolite, andesite, basalt, volcanic glass, pearlite, ash, scoria, etc. The most extensive mass in the immediate environs of the valley is found in the Superstition Mountains, east of Salt River Valley, where rhyolitic flows and beds of white tuff and ash occur to an aggregate thickness of several thousand feet. The igneous rocks form a nearly vertical escarpment rising something over 5,000 feet above the valley floor (Pl. XIII, *B*).

QUATERNARY FORMATIONS.

The greater part of the area represented in the accompanying geologic map is occupied by débris which is here designated "valley fill." It is unconsolidated material, accumulated in the valleys and on the gentler slopes of the hills. Since it is in this valley fill that the underground water occurs, it is, so far as this report is concerned, the formation of prime importance in the region. An understanding of processes of accumulation now in operation is necessary for an adequate understanding of certain features in the structure of the valley fill. For this reason much that properly belongs in the chapter on physiography is given in this connection.

TEMPE BUTTE, SHOWING TILTED SANDSTONE AT THE RIGHT, OVERLAIN BY ANDESITE.

A. BELL BUTTE, NEAR TEMPE.

A lava butte partly buried by valley fill.

B. NORTH END OF SUPERSTITION MOUNTAINS.

A lava promontory rising above the detrital plain of Salt River Valley.

VALLEY FILL.

At Mount McDowell Salt River emerges from the narrow canyon by which it passes through the Superstition Mountains and enters the broad bottom lands known as Salt River Valley. (Mount McDowell stands at the head of what is termed the "valley" in this paper.) Some time ago it was proposed to construct a dam across the Verde River near its junction with Salt River at Mount McDowell, and a series of borings was made across the canyon to ascertain the depth to bed rock. From the records of these borings a cross section of the

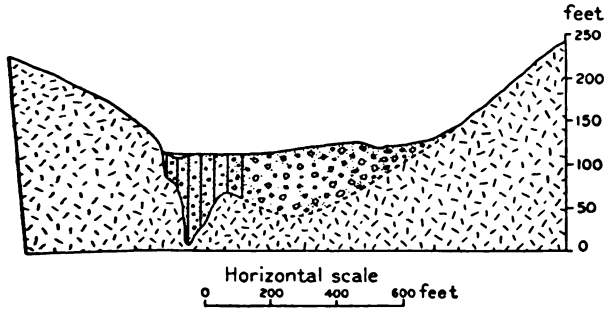


FIG. 12.—Cross section of Verde Valley near Mount McDowell, Arizona.

ancient or filled canyon of the Verde is constructed (fig. 12), showing that the valley has been filled to a depth of at least 90 feet. This valley fill is composed of waterworn material, similar to that found in the river bed and throughout the valley at the present time. This section may be taken as illustrative of the general structure of Salt River Valley. The valley, very much deeper in past ages than it is now, has been filled to its present level by fragmentary material.

STRUCTURE.

The region known as the Mesa is at the eastern extremity of the valley, lying about 25 feet higher than the bed of the river. The bluffs forming the edge of the Mesa are composed of river gravels and bowlders similar to those found in the present river bed (see Pl. IV, A). It is evident that the Mesa gravels were deposited by Salt River, and that because of some subsequent change in the abrasive force of the river, caused perhaps by a slight elevation of the surface, the river has cut into its former deposit to a depth of at least 25 feet near Mesa. How much deeper it cut remains unknown. The well at the creamery near Tempe, described in the former chapter, seems to be entirely in the recent material, though this can not be confidently stated. This degradation occurred over a strip 1 to 2 miles wide. The degraded area was again covered with débris forming the lowlands found along the river in the Mesa region. No deep wells have penetrated the more recent

deposits of the lowlands in the Mesa region in localities suitable to indicate the depth of these deposits. Shallow wells dug to a depth of about 50 feet seem to be wholly in the recent deposits, indicating that the erosion which formed the Mesa bluffs must have lowered the river bed at least 50 feet beneath its present elevation.

The two gravel terranes differ but slightly. Their constituents are the same, but the younger accumulations are notably less cemented. Wells sunk in them are the most productive wells in the region because of the readiness of movement of their ground waters. In the Mesa region the younger gravels are easily distinguished from the older on account of the former being confined between bluffs of the older material. But at Tempe and throughout the Phoenix region the younger gravels cover the older and their distribution can be judged only from the well records. The relations of the two series of accumulations are shown in sections AB and CD of Pl. XIX, and in the cross section near Phoenix (Pl. XXI).

MATERIAL.

The valley fill is composed of more or less irregular lenses of clay, silt, sand, gravel, wash, and bowlders. These are arranged in a most erratic manner, the character of the beds changing rapidly both vertically and horizontally, as indicated by the well records.

This material may be divided for convenience of description into (1) river débris, (2) sheet wash, and (3) chemical precipitate.

RIVER DÉBRIS.

In the present river bed are found bowlders and gravel of quartzite, quartz, chert, granite, gneiss, and various kinds of eruptive rock. The quartzose materials greatly predominate, owing, no doubt, to their enduring character. Bowlders occur with a maximum diameter of about 2 feet. A comparison of the material found in the river bed at the present time with the older material found in the exposed bluffs along the river and in the numerous wells throughout the valley indicates that for the most part the valley fill was derived from the same sources from which the present river gravels are derived, namely, the formations along the upper reaches of Salt River.

SHEET WASH.

The term wash is used in this region with at least four meanings, more or less separate and distinct:

(1) The stream courses occupied by water only in times of heavy rainfall, called arroyos in other parts of the West, are here called washes.

(2) Many of the dry stream courses having their origin in the mountains are well defined for a greater or less distance after emer-

ging from the mountains, but finally disappear on the plain, leaving no trace of a definite course. During times of flood the waters spread in a broad, thin sheet over the plain. The largest floods gradually find their way to the rivers, not by way of channels, for there are none, but by a broad wash over the even surface of the gently sloping plain. In most cases, however, the waters never reach the river, but are absorbed by the sands and gravels of the valley floor and disappear completely from the surface. The broad sheet of water thus sweeping over the surface is called a sheet wash.

(3) The material brought from the hills by the streams, many of them of considerable size—as, for example, Queen Creek and Cave Creek—is deposited as a broad fan, so broad and low, in fact, that it is scarcely separable from the general valley floor. Queen Creek has a well-defined course for about 50 miles, and Cave Creek one somewhat longer. During floods a large amount of débris is deposited along these stream courses and is locally known as wash. The material in which wells have been sunk is sometimes described as "Queen wash" or "Cave wash," etc.

(4) A fourth meaning of the term is closely allied with the third, and yet distinct enough to demand separate mention. The sudden heavy showers so characteristic of Arizona are too well known to require explanation. If a so-called cloud-burst occurs in the hills near the edge of the valley the small stream courses, flooded to overflowing, discharge their débris-charged waters upon the gentler slope of the valley floor, where all definite stream courses disappear. Should a channel by chance become established, the checked velocity of the water on the gentler slopes of the valley floor soon causes it to become choked and to be deflected and join that of the neighboring streams. The result is that flood waters from the hills move more or less in a sheet over the valley floor until they disappear beneath the surface. The loose material from the hillsides is thus brought to the valley and distributed somewhat evenly over the surface. Cloud-bursts which take place over the valley produce the sheet floods on a smaller scale. The material thus brought from the hills and distributed over the valley is called also sheet wash.

The term wash, therefore, applies (1) to a dry stream course, (2) to water moving in the form of a thin sheet over the plain, (3) to the material deposited by an intermittent stream near the base of the mountains in the form of a fan or dry delta, and (4) to the accumulations of detrital material working slowly from the hillsides, as a more or less evenly distributed sheet.

It is not difficult to understand how the washes can cause large quantities of débris to accumulate near the hills. But in the midst of the plain, miles from the hills, the sheet flood, as a geologic agent, might seem so unimportant as to be negligible. The heavy showers

occur but seldom and affect a very limited area at any one time. It is probable that scores of years may intervene between two showers sufficiently heavy to produce sheet floods at any given point, and yet the writer is of the opinion that the sheet flood is a factor which can not be neglected in the adequate explanation either of the valley fill or of the underground water contained in this fill.

As the arkose works its way down the mountain slopes and spreads over the surface of the plain, the coarse material naturally accumulates near the foot of the parent mountain, while the finer material is carried farther out. The sorting, however, is not carried on to anything like the extent observed in the case of regular streams. In many cases, indeed, the floods are so tumultuous that coarse and fine materials alike are carried forward and piled in confusion. In the less violent floods the coarse material accumulates near the hills. This fact is of the utmost importance in furnishing an explanation of certain phenomena connected with the underground waters of the valley.

The sheet wash is apt to differ from the stream-carried débris in bearing less evidence of the recognized action of running water. The water wear and sorting are at a minimum. When there is water enough to move any of the material of the wash, there is likely to be enough to move coarse and fine alike. The result is an accumulation of silt, clay, sand, and gravel commingled in every conceivable proportion. The gravels are usually angular, although some are slightly water worn. Near the granite hills the wash is composed of the coarse, angular products of the partial decomposition of the granite, previously described. When the feldspars are decomposed to such an extent that they do not easily retain their original form, the material is locally known as "talc" or "soapstone" (not to be confused with true talc and soapstone).

At Desert well the wash covering the surface is at least 180 feet thick, and no other material except a few feet of sand is found throughout that thickness. The 348-foot well of the Valley Seedless Grape Company, near the eastern end of the Salt River Mountains, is in granitic wash throughout most of its depth and at the bottom penetrates solid granite. In many places the wash from the hills gives character to the topography over wide areas. Southwest of the Superstition Mountains the surface of the desert over an area of something like 300 square miles is composed of wash from these mountains. The small stream courses from the mountains soon disappear in a regularly inclined desert surface which is practically wanting in even the smallest stream courses.

Queen Creek, which may be taken as a type of the streams that enter the valley from the neighboring mountains and disappear on the valley floor, illustrates the manner of accumulation of wash. It has a drainage area of about 143 square miles in the mountainous

district northeast of Florence, and its course is traceable in a distinct channel for a distance of over 40 miles, but on entering the valley the waters soon sink from view into the sands and gravels of the floor, leaving the bed dry except in times of flood. A few miles below the dam site at Whitlow's ranch the creek emerges from the hills upon the sloping plain of the valley, and thence to the end of its course follows no well-defined depression or valley. From Whitlow's ranch to the end of the course near Andrada well the creek bed has a fall of about 665 feet, making an average gradient of 28 feet to the mile, which above the ranch is still higher. With such a gradient it is evident that during times of flood great quantities of débris must be swept from the hills. The floods are in part checked as they enter the plain and in part lost by sinking into the gravels, and the débris is deposited, building up the course of the stream. The result is that numerous channels occur side by side, more or less connected by crosscuts forming a network of interlacing courses. A second result is that along the lower reaches of its course, Queen Creek has built up a fan or dry delta above the surface of the surrounding plain. A similar fan has been built by Cave Creek, the lower reaches of which are within the area covered by the detailed topographic map of Salt River Valley. The deflection of the contours south of Cave Creek, as shown on this map, is due to the general elevation of the land surface in that region caused by the Cave Creek fan. North of Sacaton Mountains Queen Creek branches into numerous forks or distributaries and is eventually lost in the general surface of the plain. From this point to the Gila River, a distance of about 15 miles, there is no stream channel. Floods large enough and lasting enough to reach the Gila pass over this last 15 miles as sheet washes. These washes are said to vary from a few inches to 2 feet in depth and the water is so loaded with silt and floating vegetation that it works its way slowly over the plain without excavating channels even where the slope is comparatively steep.

It is seldom, however, that floods occur of sufficient size and duration to reach the Gila, being more often lost in the valley fill long before reaching that river. The amount of water which thus sinks beneath the surface, together with the intermittent character of the flow, is well shown in the accompanying table and diagram (fig. 13) taken from the paper on Irrigation near Phoenix, Ariz., by A. P. Davis.[a]

[a] Davis, A. P., Irrigation near Phoenix, Ariz.: Water-Sup. and Irr. Paper No. 2, U. S. Geol. Survey, 1897.

Estimated monthly discharge of Queen Creek, Whitlow's ranch, Arizona, in 1896.

[Drainage area, 143 square miles.]

Month.	Discharge.			Total for month in acre-feet.
	Maximum in second-feet.	Minimum in second-feet.	Mean in second-feet.	
January	2	2.0	2.0	123
February	2	2.0	2.0	115
March	2	2.0	2.0	123
April	2	1.0	1.5	87
May	1	1.0	1.0	61
June	1	1.0	1.0	60
July	9,000	.....	121.6	7,480
August	1,433	.6	13.1	805
September	3,428	.5	17.1	1,016
October	1,188	.5	13.3	820
November	80	.6	1.3	80
December	207	.6	2.0	120
Total	9,000	.....	15.0	10,890

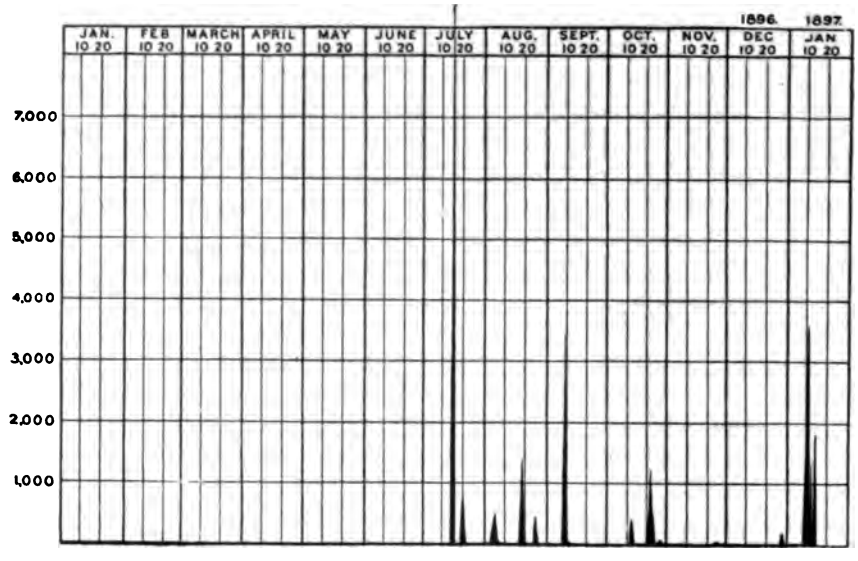


FIG. 13.—Daily discharge of Queen Creek.

Robert Bowen, who owns a ranch about 6 miles east of Harrington well, on Queen Creek, pointed out to me certain fields which were flooded a few months previous to my visit. There are 6 channels at this point, varying from a few feet to about 100 feet in width. In order to flood the fields in question the water in these channels must

have had a depth of at least 5 feet. Mr. Bowen states that at the Harrington ranch, 6 miles downstream, there was not enough water to fill certain irrigation ditches which had been prepared for the diversion of flood waters. Here then is a specific case of a flood of somewhat notable volume that sank into the sands and gravels of the valley fill within a distance of about 6 miles.

CHEMICAL PRECIPITATES.

Caliche.—In nearly every well of the valley a substance is encountered, in greater or less quantity, which is commonly known as cement or hardpan. This material is also known, though less generally, as caliche, and has been described by Prof. W. P. Blake,[a] of the University of Arizona, who says:

> In southern Arizona and in Mexico the word caliche is in general use to denote a calcareous formation of considerable thickness and volume found a few inches, or a few feet, beneath the surface soil, upon the broad, dry, gravelly plains and mesas. * * *
>
> Caliche has a wide distribution in the regions of Arizona and Mexico. It is usually hidden from view by a slight covering of soil, but it is easily found by digging, and is often revealed by a flow of water during heavy rains. It is practically a continuous sheet, from 3 to 15 feet thick, of earthy limestone or travertine, through which the smaller plant roots find their way with difficulty. * * *
>
> The top of the caliche is more dense and solid than the lower portions. The surface of this crust, or layer, is comparatively smooth, though undulating, while the lower portions, under the crust, are irregular, cavernous, earthy, and very porous, blending gradually with the materials of the sandy and gravelly beds, from which they are divided by no sharply defined plane of stratification or separation. The caliche invests, surrounds, and includes sand grains, gravels, and more or less earthy material, but seems to have had the power, especially in its upper crust, of extruding the coarse materials of the soil to a great extent.
>
> The deposit does not form a regular horizontal bed conformable with the rude stratification of the gravels and sands, but conforms roughly with the general surface, rising and falling with the undulations of the mesa. There are, in places, repetitions of the compact layers, separated by a few inches of the amorphous and more earthy deposit. * * *
>
> Close observation detects, in some places, small perforations, like pin holes, at the top, which enlarge gradually below and penetrate the entire compact crust, becoming lost in the irregular amorphous granular mass. * * *
>
> The caliche is an example of deposition independent of the influence of organic agencies. * * *
>
> In chemical composition the caliche is essentially a lime carbonate, but contains some calcium, magnesium, and aluminum silicates, as more fully shown by the result of an analysis made by my assistant, Mr. J. S. Mann, in the laboratory of the Arizona School of Mines:

[a] Blake, William P., The caliche of southern Arizona: Trans. Am. Inst. Min. Eng., vol. 31, 1901, p. 220.

Analysis of Arizona caliche.

Calcium carbonate ($CaCO_3$)	72.28
Magnesium carbonate ($MgCO_3$)	2.13
Calcium silicate ($CaSiO_3$)	5.57
Aluminum silicate ($AlSiO_5$)	7.37
Ferric oxide (Fe_2O_3)	1.88
Moisture (H_2O)	1.20
Total	96.43

This caliche, unlike the deposits of travertine formed in the open air, is not sufficiently compact and solid to be useful in construction, as was the travertine of ancient Rome. When calcined it yields good caustic lime, which, tempered with sand, makes a strong, quick-setting mortar or cement. It is quarried and used for this purpose in some places. Occurring as it does in mixture with gravel and sand, it has the appearance of an artificial mixture. * * * .

After describing local conditions and giving the analyses of water from 7 wells near Tucson, which indicate that the underground waters contain the principal elements found in caliche, Professor Blake adds:

There has been much speculation in regard to the origin of the caliche. It has been generally assumed to be a deposition from some ancient lake, or body of water, once covering the area in which it is found. But such a theory is untenable when all the phenomena are considered. The formation is clearly the result of the upward capillary flow of calcareous water, induced by constant and rapid evaporation at the surface in a comparatively rainless region.

With a constant supply of phreatic calcareous water, the second great essential factor in the formation of caliche is the continued desiccating atmosphere—a condition which prevails, with only short and temporary exceptions, through the year. The desert and semidesert regions of Arizona are characterized meteorologically by the unusual dryness of the air and its capacity for the absorption of moisture and by the maintenance of continued evaporation from the soil, which determines a constant upward movement of the phreatic water. The occasional rains in midsummer and midwinter do not penetrate to great depths, but are sufficient to leach out the soil to the depth of a few inches or feet, turning the calcareous solution back and downward and producing the denser upper crust, where it meets the upward flow.

Such I conceive to be the origin of the caliche. It may be called a subterranean deposit of travertine; but it is not the result of a flow from springs or from any source at the surface, or from the lateral movement of water. Unlike ordinary travertine, it is the result not of descending but of ascending currents. The ordinary conditions of vadose circulation are reversed. The caliche is a fine example of the formation of extensive calcareous strata in the midst of preexistent beds, not by metasomatic processes, but by precipitaton from sources below.

To Professor Blake's description I would add that caliche occurs in varying degrees of purity and that any consolidated layer is locally known as cement. When caliche is not mixed with a considerable amount of foreign material it may become very compact, resembling a fine-grained limestone, and sometimes causes much difficulty in sinking wells through it. Several cases are on record where wells were abandoned because the casing caught on a cement layer and could be forced no farther.

A sand or gravel bed cemented with this material often becomes impervious to water. The confining strata above the water in nearly all the wells of Salt River Valley, where water is found under pressure, contain more or less caliche in the form of a cementing material.

It will be noted that according to Professor Blake's interpretation the caliche is due to the deposition of compounds gathered from some outside source and brought in solution, through underground passages, to the region where they are deposited through the agency of surface evaporation. Applying this explanation to the origin of the caliche layers in the valley fill of Salt River Valley, it is evident from the analyses of waters already given and from the rocks previously described, which furnish by their decomposition the elements brought into the valley by the waters, that all elements necessary for the formation of caliche are present. The prevalence of caliche at or near the surface strengthens the postulate that the surface is its natural place of formation. Since the valley fill, as explained elsewhere, is due to the gradual filling of the valley by débris shed from the hills, each horizon throughout its depth has at some former time been the surface. Hence the presence of caliche bands at all horizons.

It should be noted, however, that bicarbonates are present in nearly all the waters of the valley. A relief of pressure alone is sufficient under certain conditions for the escape of carbon dioxide, which causes the bicarbonates to change to the comparatively insoluble carbonates, which are then readily deposited. It is entirely possible, therefore, that the deposition of caliche may take place at some depth beneath the surface, in fact at any depth where the pressure upon water containing bicarbonates in solution is sufficiently relieved and opportunity given for the escape of the gas.

The postulate that caliche is in some cases at least deposited without the influence of surface evaporation, is strengthened by the observation of uneven porous structures on the under side of caliche layers. This strongly suggests the deposition of caliche beneath, after the impervious layer had been formed. A lowering of the water table during dry cycles, such as are known to occur, would naturally leave beneath a caliche layer which had been formed near the surface a space occupied by loose gravels, no longer filled with water as before. The caliche layer would prevent any great amount of evaporation, but probably would not prevent relief of pressure upon the water in the gravels beneath. A relief of pressure might cause a loss of carbon dioxide and result in deposition of the insoluble carbonates.

A case in hand is found at the Murphy-McQueen pumping plant (see p. 12). Beneath the 13 feet of soil at the surface coarse gravels and bowlders occur to a depth of 34 feet. The material in the upper 13 feet is free from any notable amount of caliche, while the loose

gravels and bowlders are more or less cemented. The bowlders are encased somewhat uniformly in a white crust of caliche, often thick enough to unite them into resistant masses; the cementing is irregular, however, uncemented portions being found throughout the mass. Accepting the postulate of surface formation of caliche through the agency of evaporation, the soil above should be cemented. This is not the case. On the other hand, accepting the postulate of deposition of this caliche at some former time when the bowlders were at the surface, it is inconceivable that the caliche should be as irregularly distributed as it is. It is known that there has been a lowering of 12 feet in the underground water at this place in the last four years. There is every reason for believing that at some time the underground waters filled the gravels up to the bottom of the soil layer, and that a subsequent fall of these waters from the soil layer left a bed of loose gravel above the surface of the underground waters where these waters were not only under no pressure but were lifted to some extent among the loose gravels by capillary action, where they would naturally deposit their contained minerals on the surface of the gravels. Cyclic oscillations of the underground water would distribute this action through a considerable depth.

On the other hand, caliche is present on the hillsides far above the reach of any permanent supply of underground water. It is found generally along the slopes of the hills and over dry plains such as that in the vicinity of Desert well, where no underground water is found within hundreds of feet of the surface. (Water is found at a depth of 212 feet at Desert well and 284 feet in the Kleinman well.) Caliche found at the surface of this dry plain and on the barren hillsides can scarcely be due to the evaporation of water which can in any sense be called an underground supply as postulated by Professor Blake.

A somewhat different view is held by Prof. R. H. Forbes, director and chemist of the agricultural experiment station of Arizona, who has given the subject considerable study from a chemical standpoint. At the writer's request he has furnished the following statement of his opinion:

My view of the formation of caliche is that in this region of scanty rainfall, which penetrates the ground from a few inches to a maximum of a very few feet—say 3 or 4—the rain water, containing a small amount of carbon dioxide, percolating from the surface to this maximum depth of, say, 3 feet, dissolves small portions of calcium and magnesium bicarbonates in the form of normal carbonates, leaving in course of time a layer of limy hardpan at the depths to which it penetrates. The large amount of siliceous material found in caliche layers indicates also that colloidal clayey materials are carried down mechanically by percolating rainfall, the result being the mixture of siliceous calcareous materials, together with portions of original soil in situ, which are found to constitute nearly all of our caliche layers. The different layers found at different depths below the surface mark the various levels which for geologic reasons remained constant for a long enough period of time to permit the formation of a layer of caliche just below the surface of that time. I have noticed also that

igneous rocks at the base of hills containing calcareous materials are often coated with a thin layer of calcareous materials, evidently carried in solution in carbonated waters from higher levels and deposited upon these rocks, over which this drainage percolated, through the agency of evaporation, aeration, or heat.

It should be noted that while the two hypotheses attribute the origin of caliche to the deposit by evaporation of salts held in solution, they differ in this: Blake's postulate assumes a more or less definite underground flow bringing the materials from a distance, while Forbes's postulate assumes that the materials are taken into solution at the surface through the agency of carbonated rain water, held in solution but a short time near the surface, and deposited by evaporation at no great distance from the place of their origin. Each postulate seems satisfactory in certain cases and unsatisfactory in other cases. It seems probable that many of the caliche layers of Salt River Valley have been formed from the carbonates and other salts held in solution in the underground flow, as postulated by Blake. It seems equally evident that the caliche of the hillsides and the dry plains has been formed in some such manner as that described by Forbes.

There are still other cases where deposition of caliche evidently takes place in subterranean cavities where evaporation can have little influence, either because of relief of pressure, as previously suggested, or from some other cause not yet recognized.

Salts.—In addition to the caliche considerable quantities of the various salts found in solution in all of the waters of the valley have been deposited in the valley fill. While they are quantitatively unimportant from a geologic standpoint, they are of the greatest importance in influencing the character of the water. The principal salts are sodium chloride (common salt), calcium and magnesium sulphates (hardness), and calcium carbonate (lime). The salts are irregularly diffused through the materials composing the valley fill, and their amount, kind, distribution, etc., will be described more in detail in connection with the chemical character of the waters.

AGE OF THE VALLEY FILL.

The physiographic relations of the valley fill indicate that it is comparatively young, but no fossil forms have been found in any of the deposits. As already indicated, there are at least two periods of accumulation represented at the surface. During the accumulation of over 1,300 feet of the detrital material it is possible that there were more than two such periods. Good exposures are wanting in Salt River Valley, but similar deposits are widely distributed over western Arizona, and a comparison with regions where the recent deposits are better exposed seems to throw light on the question of age. A similarity in the succession of events recorded indicates that certain sur-

face movements have been somewhat general over a large portion of western Arizona.

The Colorado River probably furnishes the best index available to the general surface movements of the Southwest. In an examination of northwestern Arizona, described elsewhere, the author noted at numerous points a series of tilted and partly consolidated conglomerates and breccias, overlain by more recent and unconsolidated sands and gravels, which were in turn dissected and overlain by a third series now accumulating to form the present lowlands along the Colorado River. The older series is extensive both in thickness and areal distribution. Its original thickness must have been at least 2,500 feet, remnants being now found 2,300 feet above the river, and it extends downward to some unknown depth beneath its bed. The next younger deposits are less extensive, and the youngest form the present flood plain.

The succession of events recorded in these deposits as well as in those of Salt River Valley and elsewhere is indicated in fig. 14. The original valley (A) was filled with the oldest débris (B), and this in turn was eroded (C) and again filled with the second accumulation (D). A third stage of erosion excavated the present valley (E), and the deposits now accumulating are represented in stage F.

A similar succession of events has been noted at several points in Arizona, notably along San Pedro, Santa Cruz, and upper Gila rivers, and in Tonto basin, as well as in a number of places in northwestern Arizona. Near Benson, in San Pedro Valley, wells have penetrated the valley fill to a depth of about 800 feet without reaching bed rock.

In the Tonto basin upland deposits of at least two periods of accumulation are exposed. The older is a coarse breccia, moderately well consolidated and more or less tilted in places (Pl. XIV, *B*). This breccia rests upon the eroded surface of the older formations and is deeply dissected in places. Against this tilted breccia rest nearly horizontal beds of more recent sediments, which are in turn dissected, large portions of them having been carried away by the more recent action of the river (Pl. XIV, *A*). Nothing was found to indicate the geologic age of either deposit, but the older is regarded as probably representing the base of the Quaternary.[a]

There have been, then, since the original formation of Tonto basin at least 5 separate stages: (1) The period of erosion, which, in part at least, formed the basin, corresponding with stage A of fig. 14; (2) a period of accumulation, during which the breccia just described was deposited, this period corresponding to stage B; (3) a period of

[a] Gilbert, G. K., Report on the geology of portions of New Mexico and Arizona: U. S. Geog. Surv. W. 100th Mer., vol. 3, 1875, p. 540.

Ransome, F. L., Geology of the Globe copper district, Arizona: Prof. Paper U. S. Geol. Survey No. 12, 1903, p. 57.

A. CLAY BANK IN TONTO BASIN, FROM WHICH CLAY WILL BE OBTAINED FOR CEMENT IN THE CONSTRUCTION OF SALT RIVER DAM.

B. TILTED BRECCIA IN TONTO BASIN.

Accumulation represented by stage B.

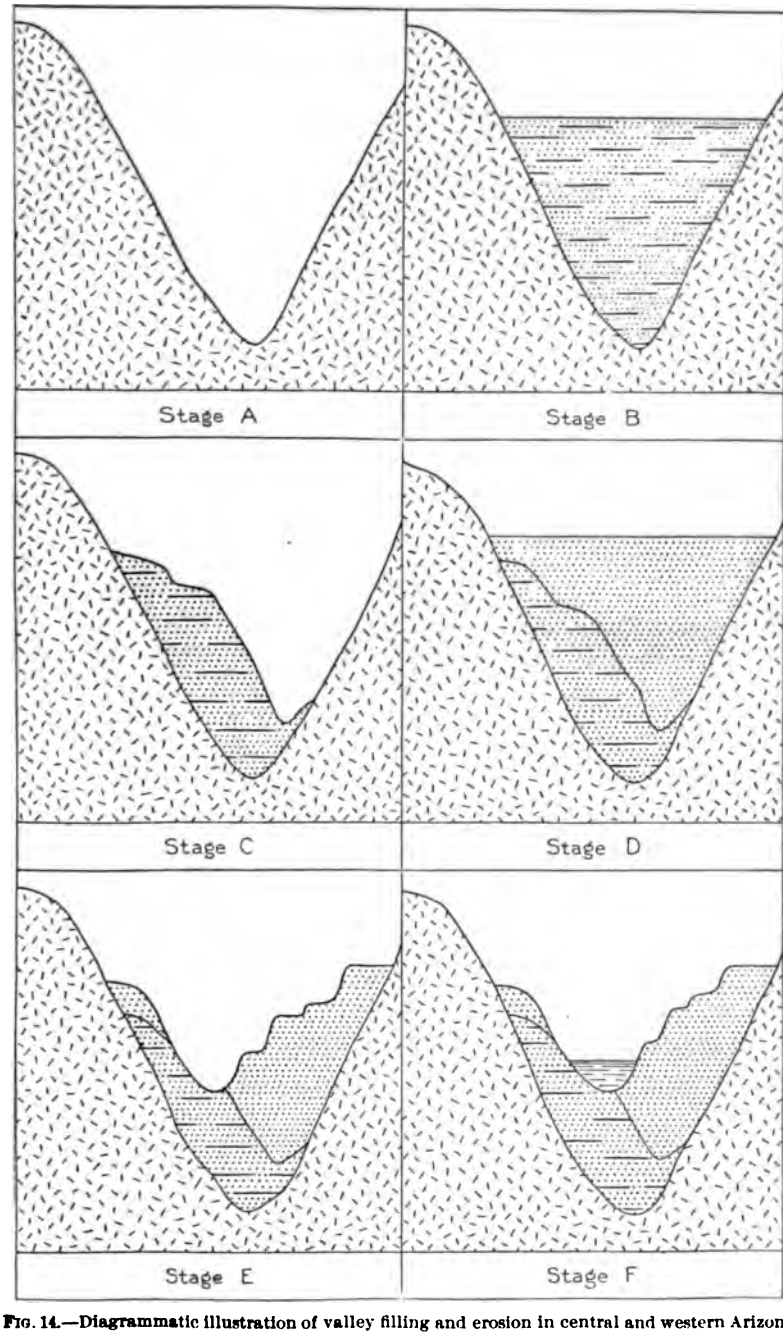


FIG. 14.—Diagrammatic illustration of valley filling and erosion in central and western Arizona.

erosion, probably inaugurated by uplift and tilting, in which the breccia was dissected, this period corresponding to stage C; (4) a period of accumulation, in which the younger sediments of the basin were deposited on or against the dissected breccia—stage D; (5) a period of erosion, the present stage of the river, during which the present valley has been excavated—stage E.

Since the same succession of events is shown to the west of Salt River Valley along the Colorado, to the east in Tonto basin, to the southeast in San Pedro Valley, etc., it is possible that the various stages are due to far-reaching causes affecting Salt River Valley in common with the other localities named.

The older mesa gravels of Salt River Valley may represent stage B, while the younger gravels represent stage D and the present river channel, stage E. There are no accumulations in Salt River Valley, except the gravels of the broad bed of the river, which can be compared to the accumulation of stage F. The similar succession of events in widely separated localities is suggestive of common causes, but no definite correlation is possible at the present time. This much, however, can be stated with reasonable confidence—the valley fill is not the result of continuous aggradation. Periods of erosion have alternated with periods of accumulation.

It is worthy of note that in the three deepest wells of the valley—the Murphy-McQueen well, 1,305 feet; the Chandler well, 705 feet; and the Thomas Murphy well, 865 feet—a considerable thickness of clay or other fine material occurs beneath the coarse detritus. In the Murphy-McQueen well this material is described as "chalk rock" and "talc." The writer has seen a small portion of the material taken from the 1,305-foot level. It consisted of clay containing a few quartz pebbles. The clay from the bottom of the Thomas Murphy well is very plastic and contains no fragments of foreign material. The clay apparently lies underneath the breccia. Little more is known of the lower horizons of the valley fill. The material of the upper horizons, so far as known, is evidently due to upland accumulation. For this reason, and because of the want of definite information concerning the lower horizons, the whole thickness of the valley fill has been assumed to originate in the same way. What little is known of the lower horizons suggests the possibility of lacustrine origin. The occurrence of the clay underneath the breccia near Phoenix suggests that the clay beds encountered in the Mesa region may be notably older than the detrital material above. In that case the lower part of the valley fill may be of Tertiary age, and a thickness of only a few hundred feet at the top may belong to the Quaternary.

SURFACE MOVEMENTS.

There is abundant evidence that changes in surface elevation have taken place in and about Salt River Valley in comparatively recent times.

(1) The immense deposits of upland accumulation in this region are best explained as due to subsidence of the surface. The general occurrence of upland accumulations of débris throughout western Arizona and southern California suggests that the same cause affected wide areas. It is probable that these accumulations are in part due to desiccation of the climate. There is abundant evidence that in former ages streams of considerable size occupied valleys which are now dry. However much desiccation of the climate may have caused a diminution of streams and consequent deposition of débris in valleys which were formerly swept clear by these streams, it can not wholly account for this accumulation.

The present surface elevation at Mesa is about 1,200 feet. The deep well at Mesa—1,305 feet—extends about 100 feet below sea level and does not reach bed rock. It is obvious that at this point the surface must have been at a greater elevation when the valley was formed, since the river could not excavate the valley below sea level. Similar thicknesses of the upland débris occur elsewhere—800 feet in San Pedro Valley; 1,000 feet in Sacramento Valley at Yucca, Ariz., and about 2,400 feet exposed in the bluffs of the Colorado River. In none of these places, however, is bed rock reached. The evidence points to a general subsidence as the initial cause of the upland deposits.

(2) Local movements. The sandstones and the breccia near Tempe and at Mount McDowell, near the head of the valley, are highly inclined. The attitude of the sediments in Tonto basin indicates faulting and tilting to a notable extent, and Ransome[a] describes an area of intense faulting and movement east of Salt River Valley. Faulting and block tilting are not easily recognized in crystalline formations such as those immediately surrounding the valley, and the covering of detrital matter renders the location of possible fault lines doubtful. Reasoning, however, from analogy it is probable that faulting and block tilting have played a considerable part in bringing about present relations in and near Salt River Valley.

The most conspicuous example of a tilted block within the valley is found in Tempe Butte, where the sandstone and its overlying sheet of andesite are tilted steeply to the south. The movement which brought this butte to its present position was very recent. Waterworn bowl-

[a] Ransome, F. L., Geology of the Globe copper district, Arizona: Prof. Paper U. S. Geol. Survey No. 12, 1903.

ders, such as compose a large part of the valley fill, are found on t
sides of the butte above the level of the valley floor, and although th

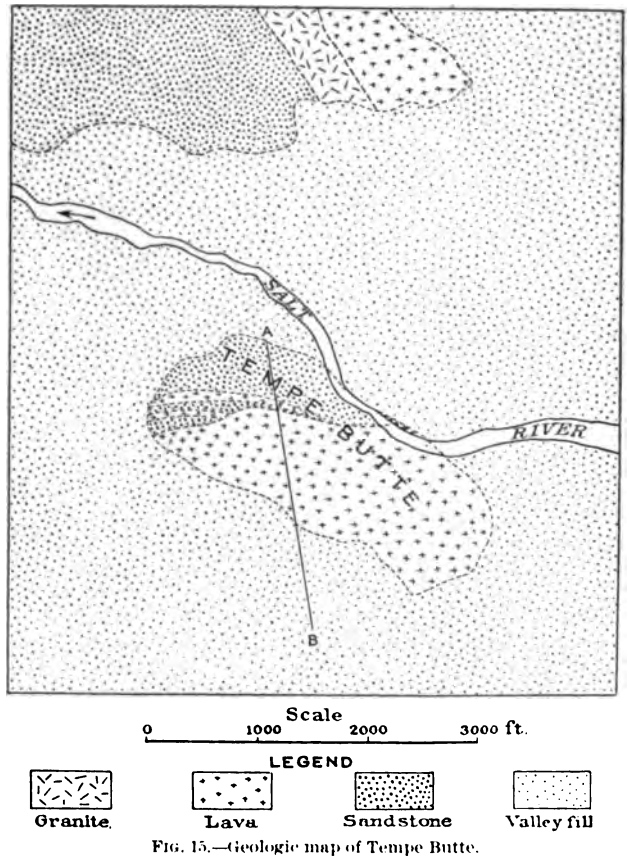


FIG. 15.—Geologic map of Tempe Butte.

lie loose on the steep sides, sufficient time has not elapsed since the
elevation to allow of their finding their way back to the river whi

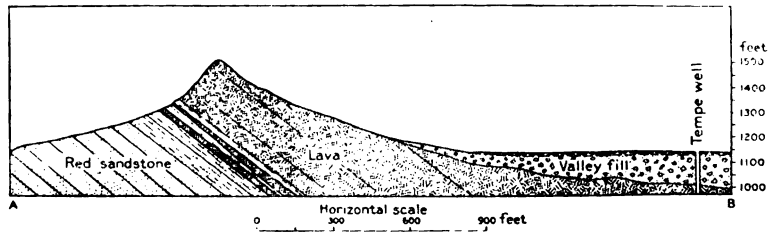


FIG. 16.—Section through Tempe Butte and Tempe well.

flows at the foot of the butte. The attitude of the formations and the
relations to each other are indicated in figs. 15 and 16.

CHAPTER III.

PHYSIOGRAPHY.

MOUNTAIN AND PLAIN.

The so-called valleys of Salt and Gila rivers are but parts of a broad plain occupying a large portion of southwestern Arizona. The valleys are in part surrounded by mountainous areas, and they themselves in turn surround isolated peaks and groups of mountains which rise abruptly from their surface. To the north and east the country becomes more and more mountainous to the edge of the high plateau, which within a distance of something like 80 miles rises to an elevation of about 7,500 feet, as indicated in the sketch profile fig. 17. The escarpment bordering the great western plateau passes through this region. The surface of the plateau slopes northward, while the drainage from its face—the edge of the Mogollon Mesa—together with that from the broken country to the southwest of the escarpment forms Salt and Verde rivers, thus furnishing the water which supplies Salt River Valley. In a general way the aggraded

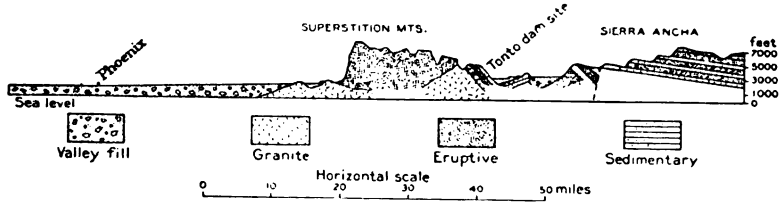


Fig. 17.—Sketch profile from the Agua Fria, through Tonto basin and the Sierra Ancha.

plain of which Salt River Valley is a part lies at the foot of the escarpment bordering the plateau, and has been filled and graded principally by material shed from the edge of this plateau. Between the escarpment proper and the aggraded plain there is much broken country of which little is known. Toward the south and west of the escarpment the mountain masses stand out as more or less isolated groups, separated by stretches of fairly level plains, as, for example, the Salt River and Sacaton mountains.

The plain from which these comparatively small mountain groups rise has a regular and moderately uniform slope corresponding to the gradients of the streams. In some cases the transition from mountain to plain is marked by a series of partly buried hills, which were

originally outlying remnants of erosion and which have since been surrounded by débris shed from the mountain slope. This is illustrated in a small way south of the Phoenix Mountains (Pl. XV). In a larger way the groups of mountains, such as Salt River Mountains, Sacaton Mountains, etc., are also remnants of erosion partly buried by débris. In other cases the mountains rise from the graded plain or valley floor with the utmost abruptness, as in the case of Bell Butte (Pl. XIII, *A*), and Camelback Mountain (Pl. XVI, *A*). Probably the most notable physiographic feature of the region is the abrupt transition from mountain to plain.

In the views, previously referred to, of Tempe Butte, Bell Butte, etc., the aggraded plain shown in the foreground extends to the abrupt rocky slopes with little or no transition. Irrigable lands extend to the foot of the slopes, as indicated in Pl. XVII, which is a view from the top of Tempe Butte. The explanation of these relations is found in the study of the material and structure of the valley floor. The old valley has been flooded with débris and the outlying peaks and spurs partly or wholly submerged.

THE MESA REGION.

The Mesa gravels, or older gravel accumulations, were deposited to an elevation 25 feet or more above the present river bed. Later these gravels were cut by the river to a depth of at least 75 feet, and this

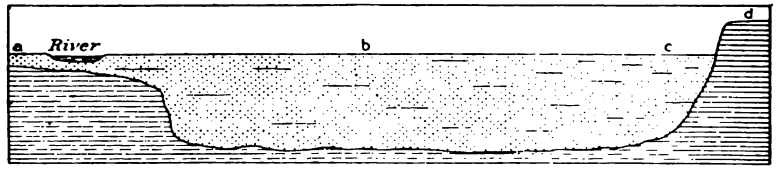
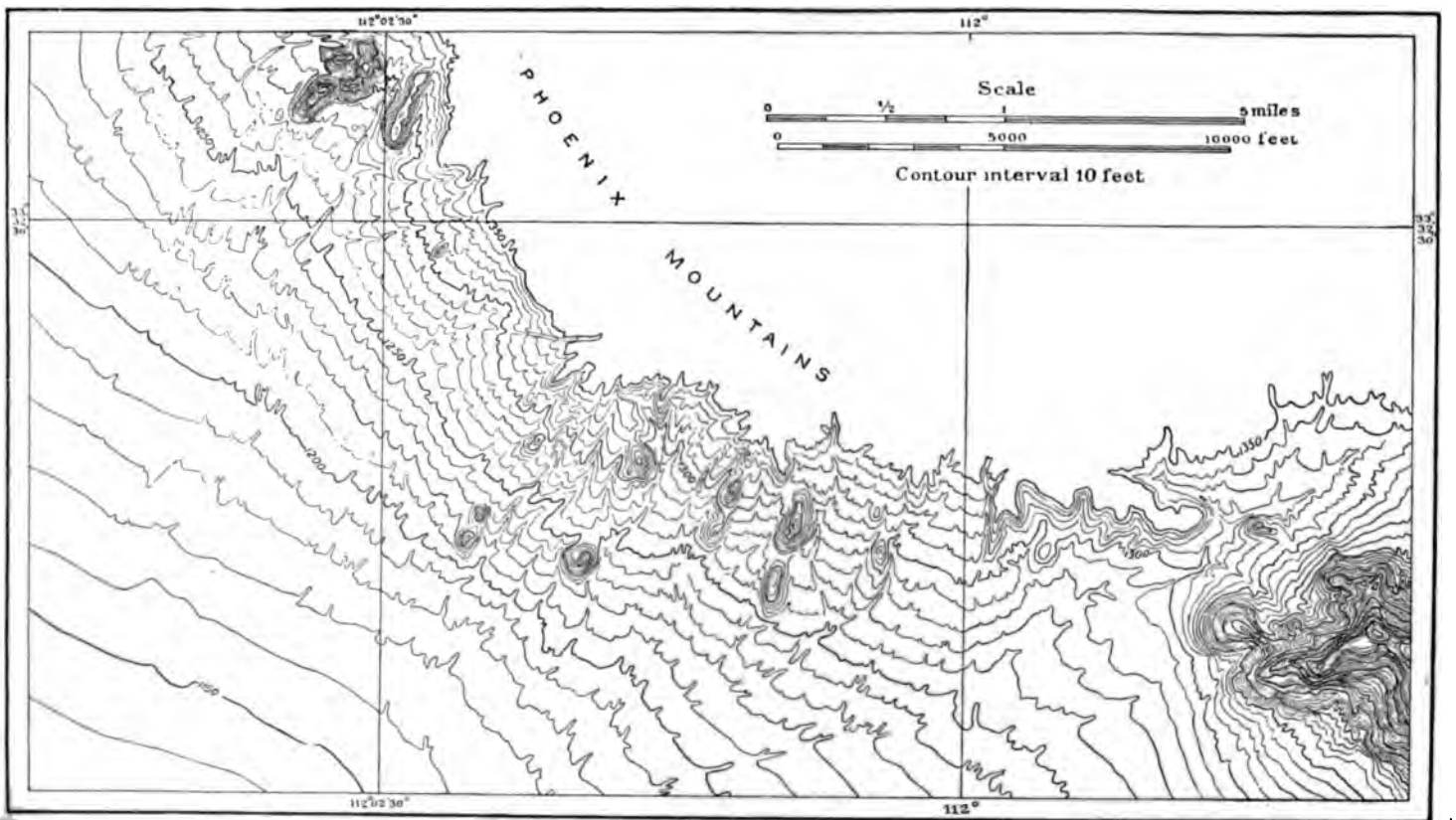


FIG. 18.—Sketch section illustrating the restricted area of water-bearing gravels due to underground structure. The older accumulation (stage B) was dissected (stage C) and the valley filled (stage D).

depression widened several miles. Later still this degraded area was partly filled. There is, then, an old valley filled with débris in which a younger valley was excavated, to be, in turn, itself filled with débris. It may be best explained, in this connection, why certain wells are productive while others in seemingly as good positions fail. If the old valley fill—the Mesa gravels—had become impervious by the deposit of silt or caliche, or from any other cause, and the present river gravels had remained unconsolidated, a water-bearing stratum of restricted distribution would occur, corresponding in extent to the recent gravels. If the recent gravels had filled the secondary valley and spread over the older accumulations, wells sunk in the strip covered by the recent gravels would be productive while wells outside of this strip would be unproductive. This is illustrated graphically in fig. 18.



MAP OF BASE OF PHOENIX MOUNTAINS, SHOWING SMALL OUTLYING POINTS PARTLY SUBMERGED IN DÉBRIS.

A. CAMELBACK MOUNTAIN FROM NEAR POWER HOUSE ON ARIZONA CANAL. RISING ABRUPTLY FROM DETRITAL PLAIN.

B. SEEPAGE LAND NEAR TEMPE.

VIEW EASTWARD FROM TEMPE BUTTE.

The valley thus filled with débris may or may not correspond with the present course of the river. Changes in the river's course over an aggrading area are the rule rather than the exception. Old channels, therefore, which do not correspond with the present river's course are to be expected in the valley fill, and incidentally these old channels are likely to give the most productive wells. The old débris-filled channels may be narrow like the present channel of Salt River near the upper end of the valley, or may be miles in width according to circumstances.

In the accompanying sketch (fig. 18) the lined area represents the older gravels and the dotted area the younger. If both be pervious, wells will yield water whether put down in the ancient or the recent gravels. If, on the other hand, the older gravels be consolidated by the deposition of caliche or otherwise and thus made impervious to water, a well at *c* would yield water while a well at *d* would yield none. At *a* the well would strike water near the surface but would soon enter nonproductive material. Examples similar to these are familiar in the construction of wells throughout the valley.

WATER TABLE.

Mesa Township was selected as being the most favorable, all things considered, for testing the regularity of the water table and its relation to the land surface. Every well was measured and the data were tabulated and placed on the map. From these data the water table of Mesa Township has been constructed in contour, and appears on the map (Pl. XVIII).

Several special features are to be noted in connection with the water table. As indicated by the sections the line representing the water table and passing through the town at right angles to the river (CC) is horizontal and at the level of the water in the river. The lines representing the water table drawn parallel to the river (AA and BB) indicate a uniform slope downstream, but the gradient of the water table is lower than the gradient of the river, and the water table approaches the surface downstream as far as Tempe, where a break occurs which is described later. On the other hand going upstream the water table becomes progressively farther beneath the surface.

From this township as a center the investigation was pushed in every direction and from the data furnished by well records given in part in Chapter I the water table has been constructed in contour for the greater part of Salt River Valley (Pl. XX).

By an inspection of the tables and of the maps constructed from these tables it is seen that the surface of the underground water is a comparatively regular plain, sloping in general with the grade of the

river, the rate of fall averaging about 10 feet per mile. The cross sections of Mesa Township (Pl. XVIII), where the wells are numerous, indicate that a line projected across the water surfaces in the wells in any direction is practically a straight line, and furthermore that the water level in any well is practically the level of the river bed at the point nearest that well. This is modified in certain cases near the river, which are described later. So regular is the surface of the underground water that the depth to water at any point of known elevation can usually be foreseen with considerable accuracy.

The water table as here described is not necessarily the same as the water-bearing stratum. For example, the water table at some particular point may be 30 feet beneath the surface. Water may or may not be found at that depth, but if found at a depth of 40 feet it will rise 10 feet in the well, and if found at 100 feet it will rise 70 feet in the well.

The shallow wells have an annual and a cyclic variation. During the dry summer season the water lowers more or less, and the shallower wells become dry. During seasons of more abundant rainfall the water level rises again. There are several facts connected with this annual variation which are worthy of note:

(1) The stage of lowest water is not coincident with the driest season, but is reached some time after the rains begin.

(2) The water in the wells seems to stand at its maximum height far into the dry season.

(3) The variations in water level can not be due to rainfall in the valley for the obvious reason that not enough rain falls to supply the quantity of water represented by the variations, even if it all joined the underground water.

As a matter of fact very little of the water falling as rain in the valley can enter the wells, except in certain localities where wells are obviously fed by surface water. The impervious layers of caliche common throughout the valley would prevent a great amount of surface water from joining the underflow, even if evaporation allowed an appreciable amount to remain permanently in the soil.

The only supply of water that is quantitatively adequate to explain the phenomena is that from the river and from the flood waters entering the valley from the surrounding hills. Waters move through sand and gravel very slowly, and a greater or less time, differing according to circumstances, must elapse after the floods enter the valley before their influence can be felt in the wells. Theoretically, there should be a retardation, or lagging of effect, and such is found to be the case in the variations of the water level.

The cyclic variations may be explained in the same way, but less accurate knowledge is obtainable than in the case of the annual variations. During the past few years the shallow wells throughout the valley have been lowered repeatedly. South of Tempe, where the

U. S. GEOLOGICAL SURVEY
PHOENIX
PHOENIX
HAYDEN
CANAL
1187
1176
1178
1174
1181
1173
1175
1177

MAP

water level is said to have been formerly within 2 feet of the surface, it is now 8 feet. At Mesa it has lowered 12 feet in four years; at the Phoenix Indian School it has lowered 20 feet in ten years. This is commonly attributed to the drought which has prevailed during the past few years. It may be partly due also to the increasing number of wells in use. The quantity of ground water is not unlimited and the operation of a large number of pumps must in time affect the supply.

The deep wells which draw their water from the lower water horizons vary to some extent, but little is yet known of them. The water level in Mr. Olsen's well rose 2 feet in less than three months, February 1 to April 14, 1903. The water in Desert well has been rising for the past eight years—during the time when the shallower wells of the valley were being repeatedly lowered to obtain water. The deeper water-bearing beds naturally draw their supply from points farther out toward the borders of the valley and the waters may have a greater distance to travel through the valley fill than those of the surface flow. It is possible also that the zigzag course which the water may follow in the valley fill is a matter of much importance. If the ideal section given in fig. 3 represents actual conditions, water from the river would pass laterally six times partly across the valley before reaching the lowest gravels. At the rate of flow as described later on it might take many years for water to make such a journey. The waters of any particular flood may not reach the deep wells until several years after the flood occurs.

It is likely, however, that the water level in a particular well would be affected by a flood long before the waters of that flood actually arrived at the well. Much as a wave may travel faster than the water composing the wave, so there may be waves or pulsations in the underflow due to the entrance of flood waters. The smaller pulsations—the annual ones—might and probably do appear in the shallow wells. These smaller pulsations may become imperceptible where they travel far, and may merge into cyclic pulsations, which alone affect wells far from the source of supply—for example, the Desert well.

On account of these variations of the water table certain allowances must be made in applying the accompanying maps which indicate by contours the elevation of the water table and the depth of this table beneath the surface. At a certain point, for example, the depth to water was 20 feet when the map was constructed. At some future time the depth may be greater or less than 20 feet according as the volume of underground water may have increased or diminished.

THE RIVER AND THE UNDERFLOW.

The river is considered the most important source of the underflow. There is a permanent water supply in it from the head of the valley to

the Tempe canal, north of Mesa. Below the head-gates of the Tempe canal a short space occurs in which the river is practically dry for the greater part of the year. Farther downstream underground water returns to the river bed; that is, the river cuts beneath the water table and the underflow returns in part, making a surface flow of something like 35 second-feet. It is evident, therefore, that from the head of the valley to the Tempe canal the surface flow of the river is at a higher level than the general surface of the underground water on either side. Wells sunk near the river indicate that the depression

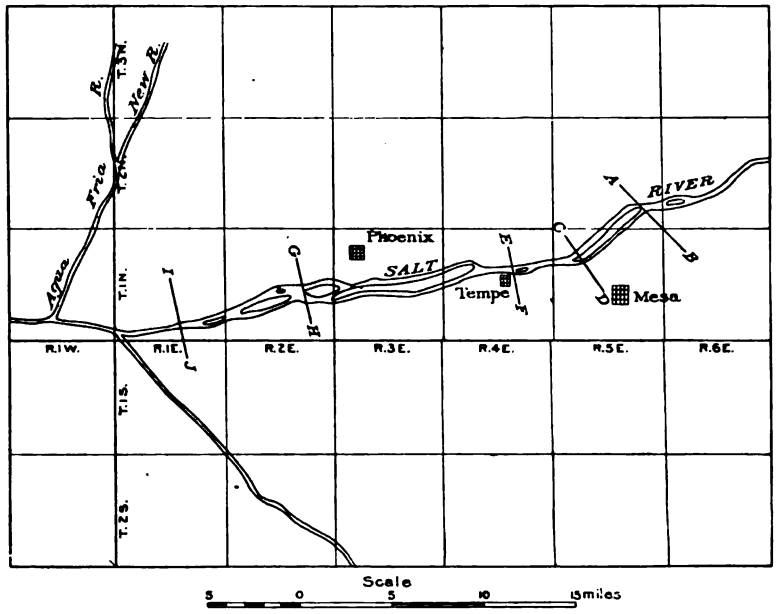
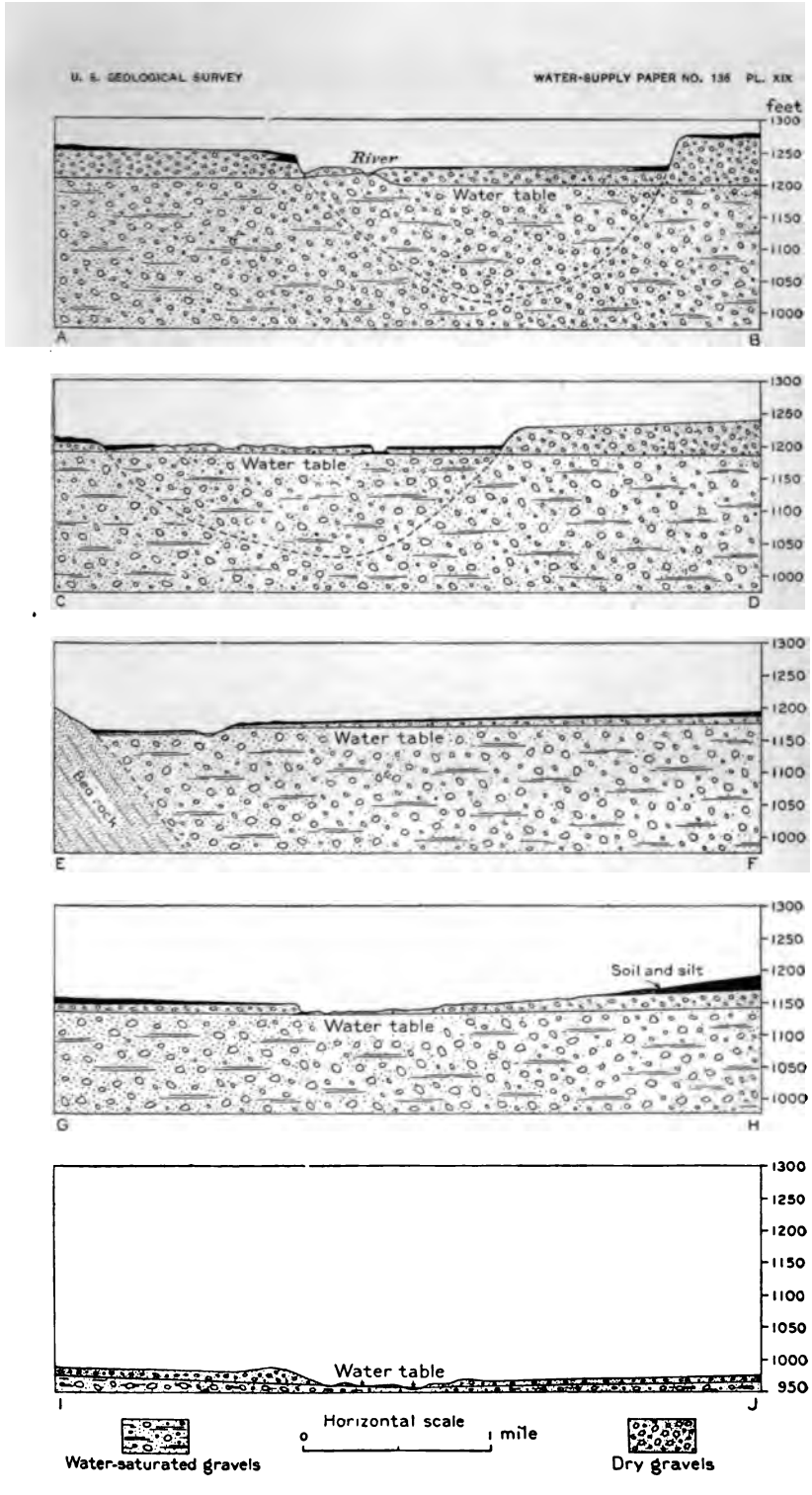


FIG. 19.—Index map of Salt River Valley, locating the sections shown in Pl. XIX.

of the water table from the river laterally is very abrupt. This is indicated by the contours of the water table as given on the map, Pl. XX, and in the sections of Pl. XIX. The fact that a permanent flow of water exists in the river at the upper end of the valley at an elevation higher than the surface of the underground water of the valley in general is of prime importance in understanding how the water enters the valley fill.

North of Mesa the river bed is at the same elevation as the water table, while at Tempe the river bed is below the water table. This explains the return of the underflow to the surface, making a perennial stream at Tempe, while the river bed both east and west of Tempe is dry. The reason for the approach of the water table to the surface near Tempe requires further explanation.



SECTIONS INDICATING RELATION OF WATER TABLE TO RIVER AND LAND SURFACES.

COURSES OF THE UNDERFLOW.

At Tempe the river flows practically on bed rock. The andesite and the red sandstones of the butte are exposed down to the water's edge. The river passes through a narrow channel between Tempe Butte and the conglomerate hills to the north. From Tempe northward to the Phoenix Mountains bed rock appears at the surface for the greater part of the distance. Where it is not exposed it is encountered in wells at no great depth. A glance at the contours of the water table of the township north of Tempe (T. 2 N., R. 4 E.) will reveal the fact that this table is 90 feet higher east of the buttes than it is about 2 miles farther west. There is then no free passage for the underflow north of Tempe except through the gravels in the immediate channel of the river.

Southwest of Tempe, Bell Butte rises from the level valley floor about midway between Tempe Butte and the Salt River Mountains. No deep wells have been drilled between Tempe and Bell Butte to indicate the underground conditions, the nearest being that of H. L. Chandler, one mile south of Tempe. This well indicates that loose gravels and bowlders extend to a depth of at least 186 feet. This would seem to indicate a free passage for the underflow between Tempe and Bell buttes. On the other hand, there is a sharp decline of the water table to the west in this region. North of Bell Butte a depression of the water table of 16 feet within half a mile was observed. South of Bell Butte a still sharper decline occurs, depressing the water table 10 feet in less than a quarter of a mile. The line along which this depression of the water table takes place is one passing from Tempe Butte through Bell Butte to Salt River Mountains.

As previously described in D. B. Heard's well, situated at the southwest corner of section 30, bowlders were encountered to a depth of 90 feet, beneath which granite wash occurs, probably from the mountains at the south. The wells at the Valley Seedless Grape Company's vineyard, 4 miles south of Tempe, and the two wells drilled in the same region by Mr. Heard indicate that the water-bearing bowlder bed hardly reaches that point. It is evident, all things considered, that the underflow so voluminous and extensive in the Mesa region does not find free passage to the Phoenix region past Tempe.

In explanation of this, there is a belief somewhat widespread in the valley that the passage is obstructed by a subterranean dam formed either by volcanic activity or by the formation of a cement reef across the valley. After what has been said of the formation of caliche, or cement, it seems evident that the continuous passage of the underflow would prevent any cement from forming across the valley which could in any sense act as a dam, and this postulate may be dismissed without further comment. The suggestion of a volcanic dam finds some con-

firmation in the presence of the andesite of Tempe and Bell buttes. As previously described, the uplift of Tempe Butte occurred in comparatively recent time, but whether the formations of the lava of Tempe and Bell buttes and the subsequent local movements occurred after the excavation of the valley or had anything to do with the obstruction of the underflow remains a matter of conjecture. In the mind of the writer, the phenomena about Tempe find most rational explanation in the change of the course of the river described below.

In order to place pumping plants where they will be most productive, it is a matter of prime importance to know the nature and course of

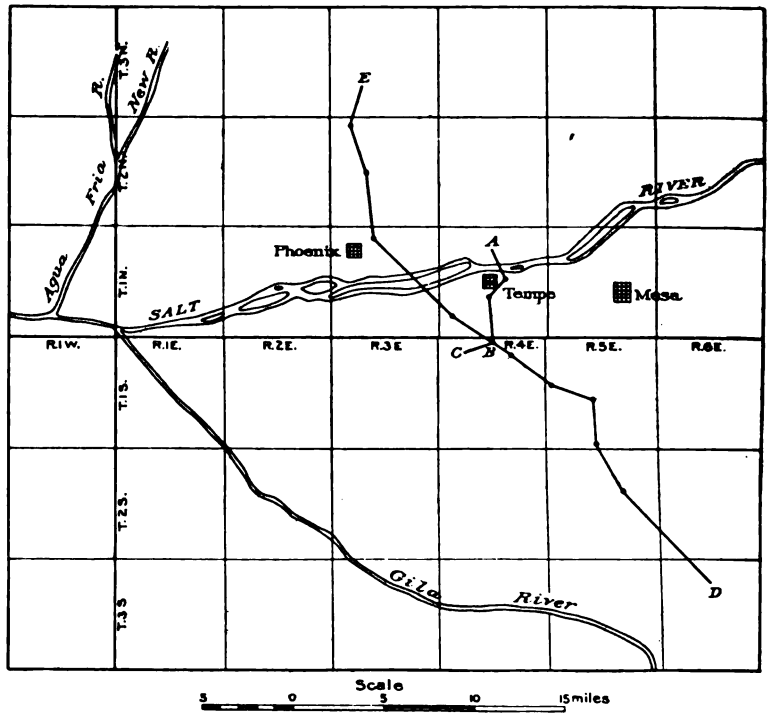


FIG. 20.—Index map of Salt River Valley, locating the sections shown in Pl. XXI.

the underflow. It is believed by some that the water is virtually stagnant and held in the gravels as water is held in a sponge. The "underground lake" is a familiar expression in the valley. A still more common expression is "the underground river." It is scarcely necessary, after what has been written, to explain that no underground lake and no underground river, taken in the popular sense, exist. There is, however, a slow movement of the underground water down the valley, which is designated as the underflow. Whether the underflow is as wide and as deep as the valley fill, or whether there are certain restrictions both laterally and vertically, directing the flow in certain courses, depends entirely upon the structure of the valley fill.

There is also to be considered the possibility that the ancient course of the river was not the same as the present course. Enough has been written to indicate that there are restrictions, and that the great volume of the underflow passes through a comparatively narrow space. The valley, filled as it has been both by wash from the hills and by sands and gravels brought down the river, would naturally yield abundant water only where the valley fill is sufficiently open to allow a free passage of water. The wash from the hills along the outer portions of the valley, while coarse enough to allow free passage of water in places, is very frequently cemented to a practically impervious mass. Some wells obtain a good supply from this wash, but there are many that have failed because they were in the wash. The most productive wells are in the beds of river gravel and bowlders.

ANCIENT RIVER CHANNELS.

Since it is always the river that is making the deposits of gravel and bowlders through which water passes most readily, it naturally follows that the bowlder beds mark the ancient courses of the river. It furthermore follows that the present course of the underflow is in general the course of the ancient river that deposited the gravels and bowlders in which the underflow occurs. It remains, then, to determine the old courses as accurately as possible in order to place the pumping plants in the most advantageous localities. At first thought this course should be in general down the valley, parallel to the river. But a little reflection indicates that this is not necessarily the case. As the floor of the valley was raised by the deposition of débris, the river shifted from side to side of the valley. When the level of the rising valley floor reached the saddle of some spur or divide the river might pass over this divide, leaving its former course at one side. This is probably what Salt River has done in comparatively recent times. On this point the following facts are to be noted:

(1) In the Mesa region water-bearing gravels occur to a depth of at least 620 feet (Murphy-McQueen well) and extend at least as far south as the Chandler well No. 5, 12 miles south of Mesa.

(2) It is in these gravels that some of the best producing wells of the valley are located.

(3) There is an obstruction of some kind, as previously described, preventing a free passage of the underflow downstream at Tempe. Such well records as are available indicate that the gravel-filled valley near Tempe may be comparatively shallow.

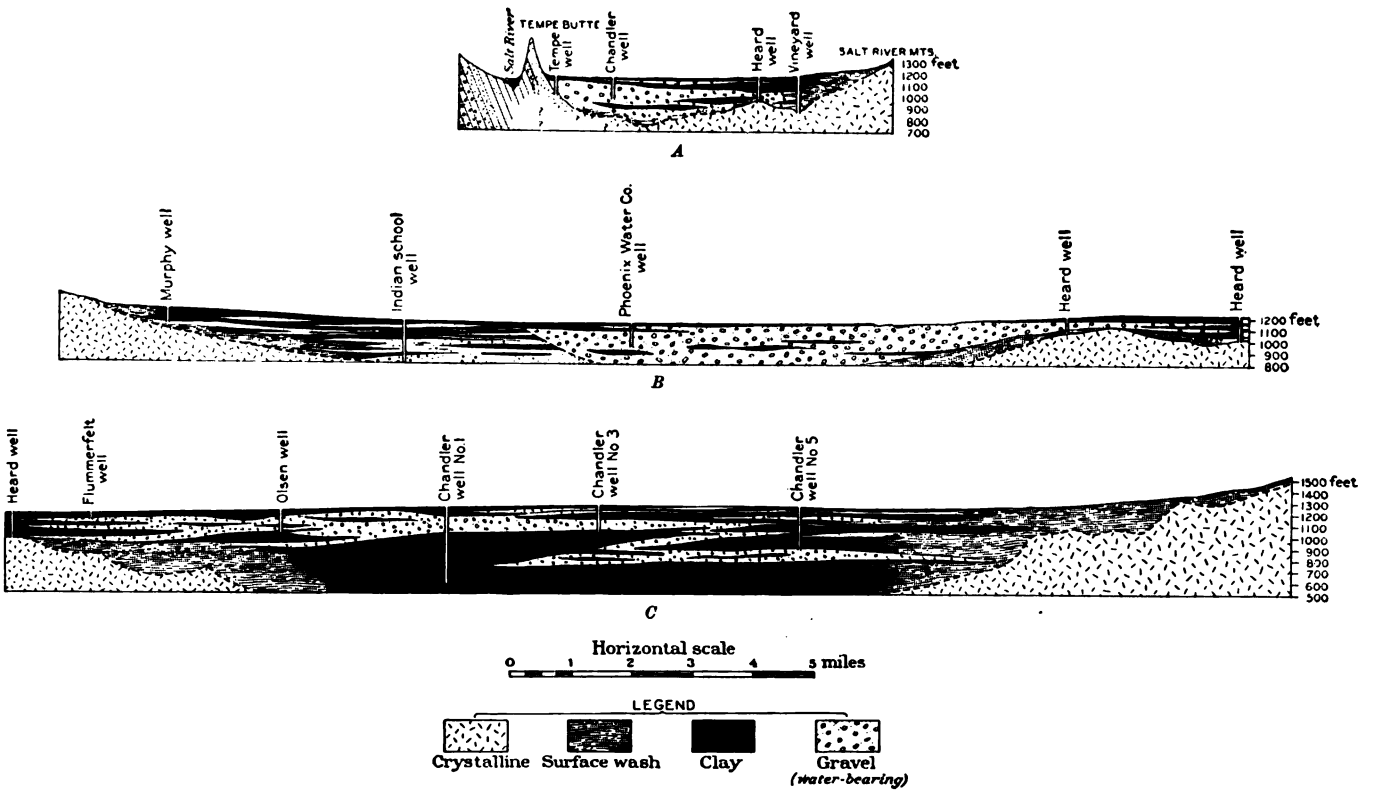
(4) Between Salt River Mountains and Sacaton Mountains is a broad and nearly level plain extending without interruption from the Mesa region to Gila River. It is an aggraded plain underlain by water-bearing gravels and connecting with the water-bearing gravels of the Gila, described in a previous paper by the writer.[a]

[a] Lee, W. T., Underground waters of Gila Valley, Arizona: Water-Sup. and Irr. Paper No. 104, U. S. Geol. Survey, 1904.

(5) At a point in Gila Valley where the waters passing as underflow through the gravels between the two groups of mountains just mentioned would naturally be expected to appear underground water returns to the surface in considerable quantity. At this point there is the somewhat novel phenomenon of a perpetual lake in the midst of a desert where evaporation is about ten times greater than the rainfall. This lake is not fed by Gila River, as is evident from the fact that the river is dry for a distance of about 50 miles above the lake during the greater part of the year. It is not fed from flood waters, since floods are seldom of sufficient volume to enter it. There is furthermore a constant and regular discharge of water from the lake. The only obvious source of supply is the underflow of Gila and Salt rivers.

An attempt has been made to show graphically the underground conditions across the valley at Tempe (Pl. XXI, *A*) and across the space between the Salt River Mountains and the Sacaton Mountains (Pl. XXI, *C*), so far as those conditions are known or can be reasonably inferred from the data at hand. It should be explained in this connection that these sections are so chosen as to pass through such deep wells as are known, thus making a section along a broken line. The depth of water-bearing gravels there indicated should not be interpreted as the depth of the passage open to the underflow. The crest of the subterranean ridge which is thought to exist is probably about a mile west of the line represented in section A, as indicated by the shallowness of the gravels at Heard's well and the sharp depression of the water table already described.

The evidence at hand leads clearly to the inference that in former ages Salt River joined the Gila east of the Salt River Mountains instead of occupying its present course north of those mountains. It has been argued with some degree of plausibility that the chemical character of the water throws doubt upon this hypothesis. The waters of the Salt River underflow as represented in the Olsen and Hansen wells, contain much greater quantities of salts than do the waters of the Gila underflow. It has been argued that waters so saline could not feed in any great measure an underflow such as that of Gila Valley. It should be noted, however, that the water from the Chandler wells farther to the east is less saline. For convenience of comparison there are placed, below, the analyses of four samples of the Gila underflow. (All water in this part of Gila Valley at ordinary times comes from the underflow.) In the same table are included the analyses of waters from the Salt River underflow, so selected as to give as wide a range as possible within the region which presumably feeds the Gila underflow. It appears from a comparison of these analyses that although the waters from the Hansen and Olsen wells are much more saline than the Gila underflow, those from the Chandler wells are



A. SECTION THROUGH TEMPE BUTTE TO SALT RIVER MOUNTAINS, ALONG THE BROKEN LINE A-B-C, FIG. 20.

B. SECTION ACROSS SALT RIVER VALLEY NEAR PHOENIX, LINE B-E, FIG. 20.

C. SECTION FROM SALT RIVER MOUNTAINS TO SACATON MOUNTAINS, LINE B-D, FIG. 20.

practically the same as the Gila underflow. It is entirely possible that the Chandler wells are in or near the course of freest flow where salts have either failed to find lodgment or if deposited in former times have been carried away by the comparatively free sweep of the waters, while the Olsen and Hansen wells may draw from water which, for some reason, is comparatively sluggish and therefore more saline, since the gravels in which it is held are not freely washed by a constant inflow of water.

Analysis of water from the underflow of Salt and Gila rivers, Arizona.

FROM GILA VALLEY.

	Lake in Gila Valley.	Cooperative Co.'s ditch, Gila Valley.	Gila River seepage.	Well at Presbyterian mission, Gila crossing.
Quantitative (parts in 100,000):				
Total solids soluble at 110° C	107.0	106.0	127.0	160.0
Chlorine in terms of NaCl (common salt)	61.2	62.8	76.4	110.8
Hardness in terms of $CaSO_4$ (sulphate of lime)	2.72	13.1	12.5	28.4
Alkalinity in terms of Na_2CO_3 (black alkali)				
Nitrogen in the form of nitrates				
Nitrogen in the form of nitrites				
Qualitative:				
Sulphates	Very strong.	Strong.	Very strong.	Very strong.
Magnesia	Strong.	Strong.	Strong.	Strong.
Lime	Strong.	Strong.	Strong.	Strong.
Bicarbonates	Strong.	Strong.	Pronounced.	Strong.

FROM SALT RIVER VALLEY.

	Chandler well No. 1 (after 15 months' pumping).	Chandler well No. 1 (after 24 months' pumping).	Chandler well No. 3 (after thorough pumping).	Olsen well.	Hansen well (after several months of constant pumping).
Quantitative (parts in 100,000):					
Total solids soluble at 110° C	127.4	179.0	84.8	381.0	442.0
Chlorine in terms of NaCl (common salt)	75.6	116.8	44.6	235.2	311.0
Hardness in terms of $CaSO_4$ (sulphate of lime)	23.1	53.3	18.5	59.84	151.2
Alkalinity in terms of Na_2CO_3 (black alkali)	None.	None.	None.	None.	None.
Nitrogen in the form of nitrates.	.07	Trace.	.266	2.0	Trace.
Nitrogen in the form of nitrites.	Traces.	None.	Traces.	Faint.	.01
Qualitative:					
Sulphates	Strong.	Very strong.	Strong.	Very strong.	Very strong.
Magnesia	Distinct.	Strong.	Distinct.	Strong.	Strong.
Lime	Pronounced.	Strong.	Strong.	Very strong.	Very strong.
Bicarbonates	Strong.	Strong.	Very strong.	Very strong.	Distinct.

PRINCIPAL COURSES OF UNDERFLOW.

While it is not probable that the underflow in this region follows a channel that is in any sense well defined, there are without doubt courses along which the flow has a maximum velocity, and others along which it has a minimum velocity. It is entirely conceivable, also, that there are places where the water is virtually stagnant. The underflow may be compared with the water of a swamp. It is one body of water, but communications between various localities are not equally free as in the case of a lake. Nor is the flow conceived to be as nearly uniform as in the case of a river. The water finds its way through the gravels along paths of least resistance, sometimes straight and sometimes circuitous. It should not be inferred, therefore, from reference to the principal course of the underflow, that anything like a definite channel is meant.

From a consideration of all available data it seems clear that the ancient course of the river and the present course of a large part of the underflow are east of the Salt River Mountains. It is probable that at a comparatively late stage in the course of the accumulation of the valley fill the gradually rising floor of the valley reached the level of the saddle between the Salt River Mountains and the Phoenix Mountains and found a shorter and easier passage than the circuitous route around the former. As the valley floor was still farther raised by the deposition of débris, and as the river passed its aggrading and degrading stages previously described, its course may have changed repeatedly, sometimes north of the Salt River Mountains and sometimes east and south of them. While the débris accumulating along its course is deemed the chief cause of the lateral migrations of the river, certain changes may have been caused by volcanic action and local movements in the vicinity of Tempe, as previously suggested.

This postulate explains in a rational and natural way the peculiarities near Tempe already described. There is probably a subterranean dam across the present valley at Tempe, which prevents the passage of the principal part of the underflow. It is not a dam thrown across a previously existing valley, but one which was formerly a ridge at the side of the valley and which was buried by débris as the valley was filled. It is probable that only the waters from the upper horizons of the gravels of the Mesa region find their way over the top of this submerged ridge into the underflow of the Phoenix region.

SOURCES OF THE UNDERFLOW.

One of the most notable features about the valley fill in the Mesa region is the thick bowlder bed covered with impervious clay. It occurs in the center of the valley, while toward the sides the bowlders

give place to the finer material. The water in the bowlder bed is under considerable pressure, while above the clay which confines it occur water bodies of limited extent, forming what is locally known as the surface flow. In certain places the surface flow is under slight pressure, while in others it is under no pressure, but the underflow and the surface flow form a single water body, as evidenced by the definite water table. The questions naturally arise: How are the waters connected? whence do they come? and how do they get into the ground?

There are several possible sources—(1) rainfall soaking into the ground; (2) underground water in the form of springs or artesian flow entering the valley from foreign regions; (3) streams and sheet washes entering the valley from the surrounding hills during times of abnormal precipitation.

(1) The rainfall is so slight—an average of little over 7 inches per year in the valley—that it could supply but a very small part of the underground water known to exist, even if it did not evaporate before entering the soil to any great depth. It is probable, however, that little if any of the water from rains in the valley finds its way to the underflow. At best it could only join the surface waters owing to impervious clay and cement layers separating these waters from those beneath.

(2) The hills surrounding the valley are composed principally of crystalline rock. There is no known possibility of water entering the valley in any form of artesian flow, and springs from the hillsides are so small that they may be disregarded.

(3) The only source which is quantitatively adequate to supply the known amount consists of the streams, chief among which is the Salt River system. There seems to be little doubt that the underflow is connected directly with the river.

In order to understand clearly how the waters enter the underflow it is necessary to know how the valley fill was deposited. In former ages Salt River Valley was a broad, deep valley of erosion, at least 1,305 feet deeper than it is at present. How much deeper, is impossible to say, for no well has penetrated beyond that depth. By some change in the altitude of the land or change of climate, perhaps both, the streams were changed from degrading to aggrading streams. The water could no longer carry all of its load. River débris accumulated as it is still accumulating. The coarser material was dropped in the channel, while the clay and silt accumulated on the floodplain, and cement formed near its surface. As the channel became choked with gravels and bowlders the stream shifted gradually, covering the clay and cement already deposited, while these materials in turn slowly accumulated over the gravels and bowlders of the abandoned stream

courses. As the river swung from side to side of the valley, gravel and bowlder beds were always left in its wake; furthermore—and this is the key to the problem—wherever a bowlder bed was formed a bowlder train filling the old channel connected and probably still connects this bed with the mouth of Salt River Canyon, whence the water, together with its débris, issued then as it does now.

While Salt River was the main factor in the formation of the valley fill the tributary streams and sheet washes played some part. Each stream, no matter how small, left a train of gravel leading into the valley fill, and in a small way migrated from side to side, as did the river. Permanent streams, no matter how small, kept a constant connection with the river, and their ancient gravel trains probably still form comparatively free subterranean passages for water into the general underflow. But nowadays the small stream courses, even streams as large as Queen and Cave creeks, do not reach the river but are lost in the valley fill. Judging the past by the present, similar relations may have obtained then. Such streams as Queen and Cave creeks might form their valley trains from the hills into the main valley for a considerable distance, and perhaps form a considerable bed of loose material through which water would flow readily, but the connection with the bowlder beds of the main stream might be cut off by impervious beds of clay or cement. Such beds might form water pockets in the valley fill, and under certain conditions yield flowing wells. However, no water pockets have been found in Salt River Valley yielding flowing water.

At the present time, while the streams are depositing their débris in the bottoms of the valleys, the granitic hills about the valley are forming granitic sand which slowly works its way down to meet the advancing accumulation of the river fill. Judging the past by the present, the outer edge of the valley fill is composed largely of granitic sand or arkose. This material is more or less pervious, and the waters shed from the hillsides sometimes sink quickly into it. Since it is only on the old flood plains that impervious clay layers were formed, these layers, so potent in the middle of the valley, where they are penetrated by the wells, do not exist near the edges of the valley, where both clays and gravel beds pass laterally into the accumulations of arkose. Thus the water, whether from the river, or from a tributary stream, or from a sheet wash from the hillside, finds its way always downstream into and through the valley fill underneath the impervious layers or wherever the trains or sheets of gravel lead.

The gravel trains thus form a network through the valley fill, connecting the principal bowlder beds, and leading back in every case to the stream which formed them. It is evident, therefore, that the underflow, although seemingly divided by impervious layers, is one

body of water, although the avenues of communication may be extremely tortuous and complicated. It thus results that the water of the underflow, whether from an upper or an under stratum, rises to a definite level which forms a comparatively uniform "water table," the gradient and local variations of the table being due to the varying resistance offered by the gravels to the passage of the water.

THE PHOENIX REGION.

The physical features of the Phoenix region differ in but few important respects from those of the Mesa region, and need be described only in so far as they differ in some essential manner. The principal part of this area consists of a broad plain, sloping gently southward to Salt River. Cave Creek enters the region from the north, and is lost upon the plain in a manner resembling that of Queen Creek in the Mesa region. At the western border of the region the Agua Fria and New River have definite channels extending over the plain to join the Gila.

DISTRIBUTION OF MATERIAL.

At the eastern border of the region granites, lavas, and the older sediments occur, as described in Chapter II. From Tempe westward to the Crosscut canal and thence northward and westward the valley fill abuts more or less abruptly against the older formations. The asylum well penetrates gravels to the depth of 110 feet without reaching bed rock, while 2 miles to the east bed rock appears at the surface. In the Murphy well, 325 feet deep, 115 feet of valley fill is penetrated, below which the breccia is encountered. Two miles to the east the breccia emerges from the surface to form the buttes north of Tempe.

In the southern portions of the region near the river the valley fill, as indicated by the well records, is composed mainly of river gravels and bowlders. It appears, from the occurrence of gravels in the Heard and McCallum wells, that the bowlder bed continues well southward toward the mountains. This southward extension is in harmony with the southward trend of the streams at the present time, as well as the southward trend of the ancient river, as indicated by the bowlder beds and the underflow of the Mesa region. While it is always unsafe to make predictions in matters so uncertain as underground conditions, the indications so far as known point to more favorable conditions for pumping south of Salt River than north of it.

A study of the well records in the light of what has already been said respecting surface oscillations, and the resulting stages of degradation and aggradation, leads to the belief that the bowlder bed underlying Phoenix is somewhat abruptly terminated at the north, as indicated in the section, Pl. XXI, *B*. The several wells in the vicinity of Phoenix enter bowlder beds differing in no essential manner from

those in the Mesa region except that they are, so far as known, comparatively free from cement. Three miles north of the Phoenix waterworks, the Indian School wells penetrate no bowlder beds nor any material that could not rationally be attributed to the action of small streams from the north and to wash from the hills. At some point, therefore, in the 3 miles intervening between the Phoenix well and the Indian School there is a transition from the bowlder bed to comparatively fine material. This transition has been shown in the section as abrupt, since the bowlder bed is regarded as equivalent to the younger beds of the Mesa region, while the finer material corresponds in age to the older Mesa gravels. During the stage of degradation intervening between the two periods of accumulation it is thought that a broad valley was cut in the older deposits similar to that described in the Mesa region, and that during the later accumulation this valley was not only filled, but the bordering bluffs were buried by the younger accumulation.

North and west of Phoenix gravel beds are few, and sand, cement, and wash make up the principal part of the valley fill. While there are a great many drilled wells in this region, there are few for which definite records were kept. The meager data obtainable are noted in Chapter I. Several wells reach gravel beds, but the extent of such gravels is unknown. Since, with few exceptions, the wells are small, being intended only for domestic use, they do not penetrate through the gravel beds. A few wells, such as the Bartlett well, the Kellner well, and the Indian School wells, have been sunk deep enough to indicate that the bowlder beds of the southern part of the Phoenix region do not extend far to the north. No accurate record of either the Bartlett well or the Kellner well is obtainable. It is thought, however, that had bowlder beds been encountered, their presence would be known, if for no other reason, because drilling machinery such as was employed in constructing these wells has proved inadequate to go through bowlders such as are found in the southern part of the region. It is probable that gravel beds of considerable volume occur, but they seem to be more or less separated. If water pockets are to be found in Salt River Valley with water under pressure sufficient to produce flowing wells, it would appear from theoretical considerations that the northern part of the Phoenix region is the place where they might reasonably be expected; but while many shallow wells have been sunk in this region, no well has yet penetrated to a sufficient depth to test this possibility. The Bartlett well, 311 feet deep, is the deepest well put down, and, according to the best account to be obtained, water under considerable pressure was encountered.

GEOGRAPHIC CHANGES.

On account of the great importance of this subject to those who may consider the construction of wells for irrigation purposes, emphasis is put on it at the risk of repetition. During stage B (see fig. 14) a thickness of more than 1,300 feet of débris was deposited in the Mesa region, closing with the great bowlder beds. During the greater part of this time, and perhaps until the close of stage B, Salt River flowed east of Salt River Mountains. The Phoenix region in the meantime was without the controlling influences of Salt River. Its aggradation was due to wash from the hills and to the débris of comparatively small streams. The material thus brought into the valley was comparatively fine; some of the larger streams formed gravel beds, but no great accumulation of bowlders took place. During stage C Salt River was flowing in or near its present course north of Salt River Mountains, and was cutting away the deposits previously laid down, and at the same time was deepening a passage through the rock ridge near Tempe. This passage is narrow, as would naturally be expected, on account of the hardness of the rock.

During the second period of accumulation (D) the new channel, or secondary valley, was filled, as was the case in the Mesa region, and since this secondary valley in the Phoenix region was now the course of the river, it was filled principally with coarse material, and to an extent sufficient to bury the bluffs, obliterating from the surface all evidence of such a valley. The recent river accumulations of the Mesa region and the bowlder beds of the Phoenix region are regarded as equivalent and directly connected through the comparatively narrow passage at Tempe.

WATER TABLE.

From what has been written it appears that the water table of the Phoenix region assumes neither the definiteness nor the importance of the water table in the Mesa region, where there is free communication between the water-bearing formations. At certain points in the Phoenix region communication seems to be wanting, as is shown in the Indian School well; at other places communication is poor. The water supply in the northern part of the Phoenix region is comparatively limited, and yet there is an inclination of the water table in places of 20 feet or more to the mile. Such a gradient could scarcely be maintained unless the passages through which the water finds exit presented formidable obstructions.

EXTENT OF BOWLDER BEDS.

The northern boundary of the bowlder bed west of Phoenix is not known. The Harris well is 7 miles west of Phoenix and 5 miles north of the river; the ostrich-farm well is 9 miles west of Phoenix and 5 miles north of the river; and the Kellner well is 14 miles west of Phoenix. The bowlder bed of the southern part of the Phoenix region was not encountered in either of these wells. It is probable that the bowlder bed will not be found much, if any, north of the Salt River canal. Thence northward the chances of finding water sufficient for successful pumping plants grow progressively less, (1) because of the increasing depth to water; (2) because of the scarcity of water-bearing material; (3) because of the limited supply of water; and (4) because of the evident want of easy communication between the various beds of water-bearing material. So far as known the underground water throughout the Phoenix region is amply sufficient for domestic use. Certain wells would probably yield a moderate supply for irrigation for a time. It is evident, however, that a pumping plant to be permanently successful must be in such a position as to draw freely from the underflow of the river, the only permanent and adequate supply. Extensive pumping would soon exhaust the limited supply from the north. If my interpretation of the underground conditions, as indicated in the history of the valley fill and presented graphically in the section across the valley (Pl. XXI), be correct, it is probable that pumping on an extensive scale would not be permanently successful anywhere north of an east-west line passing 1 or 2 miles north of Phoenix.

South of this line, however, there is every indication that pumping plants could be successfully operated. The known volume of the bowlder bed near Phoenix indicates that a similar volume is to be expected downstream. The great productiveness of the pumping plants now in operation near Phoenix, described in Chapter I, indicates an abundant water supply wherever the bowlder bed is found. The readiness of movement evidenced by the large output, and the rapidity with which the water regains its normal level in the wells when the pumps stop, indicate conditions most favorable for profitable pumping. The return of the underflow to the surface a few miles west of Phoenix and thence westward, making a surface flow of considerable volume in the Buckeye region, indicates a volume of underflow which promises permanency of supply.

CHAPTER IV.

ECONOMICS.

It remains to inquire into the practical application of the information presented in the preceding chapters. The end in view is the determination of the quantity of underground water available for irrigation, its adaptability for use in irrigation, and the best means of obtaining it. To this end I shall consider the area in which the underflow occurs, the chemical character of the waters, the volume of the underflow, the cost of pumping, and the location of pumping stations.

AREA OF PROFITABLE PUMPING.

The utility of pumping plants is determined largely by two considerations: First, the lift; and, second, the freedom of movement of the

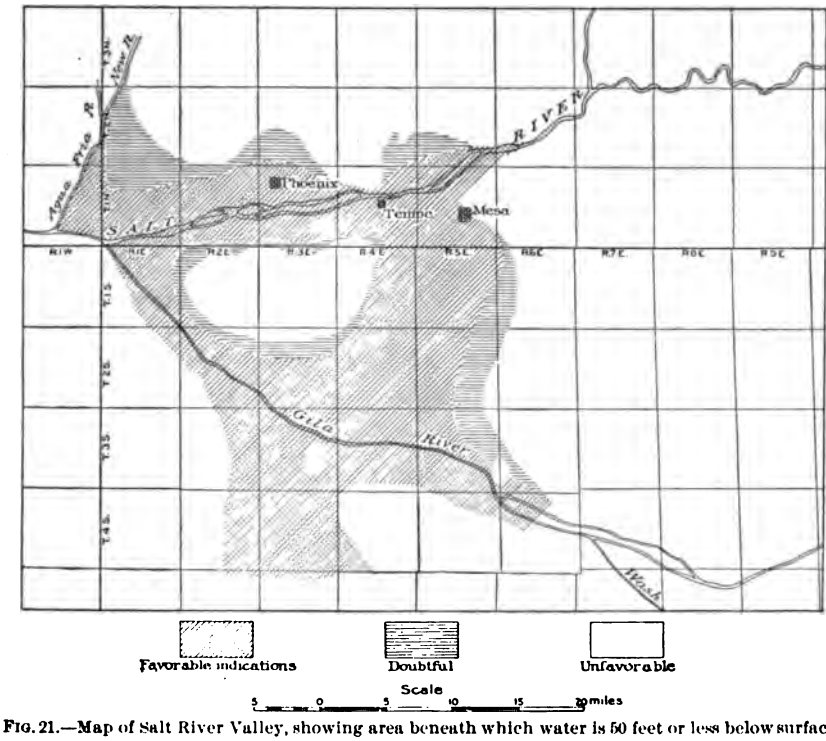


FIG. 21.—Map of Salt River Valley, showing area beneath which water is 50 feet or less below surface.

underground waters. The limit of lift, or total height to which the water may be profitably raised, can only be determined by the cost of pumping and the value of the water obtained. With certain crops

water yields larger returns than with others. On the other hand, there are localities in the valley, as shown in the last chapter, where pumping plants can not secure water from the gravels rapidly enough to make their operation profitable. The underground conditions are so variable that the selection of sites for pumping plants must depend largely on experiment in each case. In fig. 21 is indicated the area where pumping plants would probably be profitable and the area where their success would be doubtful. The line of demarcation can not be accurately drawn at present and the map should not be interpreted in this regard too literally.

The delimitations dependent on the lift can be drawn with more accuracy. Assuming a lift of 65 feet as the maximum for economic pumping, and assuming 15 feet as the average local depression of the water table in the wells through the action of the pumps, it follows that the boundary of the area thus denoted is the contour indicating a depth of 50 feet to water. The contour maps now available do not cover the southern portion of the area indicated. The boundaries are taken from the contour maps as far south as the base line; south of that line the boundaries are approximately correct. The outline of the area in Gila Valley indicating an approximate depth of 50 feet to water is also appended. This outline is taken from a map included in a former paper by the writer on the underground waters of Gila Valley.[a]

CHEMICAL CHARACTER OF GROUND WATER.

The water analyses quoted in this paper were made for the most part at the chemical laboratory of the Arizona Experiment Station at Tucson, by Prof. R. H. Forbes and W. W. Skinner. In addition Mr. Thos. H. Means, formerly of the United States Department of Agriculture, has kindly furnished a table of analyses made by himself some years ago. In so far as the analyses apply to the waters of Salt River Valley they are gathered into the following tables, arranged according to the methods of analysis:

[a] Lee, W. T., Underground waters of Gila Valley, Arizona: Water-Sup. and Irr. Paper No. 104, U. S. Geol. Survey, 1904.

Chemical analyses of waters in or near Salt River Valley, Arizona.[a]

[Parts in 100,000.]

Number.	Owner.	Location. Township.	Range.	Section.	Date.	Depth of well.	Total solids soluble at 110° C.	Chlorine, NaCl (common salt).	Hardness, $CaSO_4$ (sulphate of lime).	Alkalinity, Na_2CO_3 (black alkali).	Nitrogen in the form of nitrites.	Nitrogen in the form of nitrates.	Qualitative. Sulphates.	Magnesia.	Lime.
						Feet.									
2815	Perry Williams, Maricopa				Mar. 19, 1902	35	100	50.0	24.48	.....	Faint.	0.20	Very strong.	Very strong.	Strong.
2816	Railroad Co., 1½ miles west Maricopa				do		39.8	6.4	5.41	.....	Very faint.	.104	Strong.	Strong.	Faint.
2082	Alhambra town well	2 N.	2 E.	26	Sept. 16, 1898	50	116.3	56.0	.....	34.13	.....	.05	.....	.....	.....
2083	A. H. Smith	2 N.	2 E.	21	do	95	130.5	40.0	Strong.	.....	0.012	10.0	.....	.....	.....
2084	Frank Alkire	2 N.	2 E.	21	do	96	41.1	10.0	Strong.	.....	.0004	1.5	.....	.....	.....
2085	—— Barkley	2 N.	2 E.	17	do	90	340.8	68.0	Strong.	.....	.0084	16.0	.....	.....	.....
2086	—— Boyer	.....	.....	.....	do	80	234.5	149.0	Strong.	.....	.....	.60	.....	.....	.....
2087	W. S. McClain	2 N.	2 E.	18	do	80	117.6	29.0	Strong.	.....	.016	7.0	.....	.....	.....
2088	Town well, Glendale	2 N.	2 E.	5	do	90	79.2	39.0	Strong.	.....	.0003	.....	.....	.....	.....
2089	—— Bartlett	3 N.	2 E.	30	do	140	53.1	17.0	Strong.	.....	.....	.80	.....	.....	.....
2090	—— Mosher	2 N.	2 E.	9	do	70	346.4	112.0	Very strong.	.....	.....	1.0	.....	.....	.....
2091	G. B. Morgan	2 N.	1 E.	5	do	40	46.2	10.0	Strong.	.....	.0028	.40	.....	.....	.....
2150	B. A. Fowler	3 N.	2 E.	33	June 30, 1899	.....	80.9	13.2	36.5	.....	.....	.....	.....	.....	.....
2619	W. J. Murphy	.....	.....	.....	June 8, 1901	.....	115.8	35.6	46.11	.....	.....	.....	Very strong.	Very strong.	.....
2620	J. B. Doner	.....	.....	.....	do	.....	143.6	44.8	53.2	.....	.....	.....	Very strong.	Very strong.	Very strong.
2621	H. B. Lehman	2 N.	2 E.	6	do	.....	91.2	30.8	35.8	.....	.....	.....	Strong.	Very strong.	Strong.
2622	A. J. Straw	3 N.	1 E.	25	do	.....	188.6	81.0	.....	.....	.....	.....	.....	.....	.....
2623	A. W. Bennet	.....	.....	.....	do	.....	31.0	5.6	.....	.32	.....	.....	Faint.	Faint.	Faint.
2624	E. E. Jack	.....	.....	.....	do	.....	57.9	9.6	.....	4.35	.....	.....	Pronounced.	Faint.	Pronounced.
	MESA.														
1506	H. L. Chandler	.....	.....	.....	Nov. 24, 1896	.....	103.6	Very strong.	.....	.....	.....	.....	Strong.	.....	.....
1515	A. J. Chandler	.....	.....	.....	Feb. 1, 1897	.....	166.6	Very strong.	.....	.....	.....	.....	Faint.	.....	Faint.
1517	do	.....	.....	.....	do	.....	179.4	Very strong.	.....	.....	.....	.....	Strong.	.....	Strong.

[a] Taken from tables in The Underground Waters of Arizona, by W. W. Skinner, Ariz. Agric. Exp. Sta. Bull. 46.

Chemical analyses of waters in or near Salt River Valley, Arizona—Continued.

Number.	Owner.	Location.			Date.	Depth of well.	Total solids soluble at 110° C.	Chlorine, NaCl (common salt).	Hardness, $CaSO_4$ (sulphate of lime).	Alkalinity, Na_2CO_3 (black alkali).	Nitrogen in the form of nitrites.	Nitrogen in the form of nitrates.	Qualitative.		
		Township.	Range.	Section.									Sulphates.	Magnesia.	Lime.
	MESA—Continued.					*Feet.*									
2615	Murphy-McQueen	1 N.	5 E.	34	May 17, 1901	1,305	133.2	82.0	11.15	.....	0.0067	0.43	Very strong.	Very strong.	Very strong.
2724	A. J. Chandler	1 S.	5 E.	22	Aug. 27, 1901	150	174.2	110.7	47.02	.....	Slight trace.	.07	Strong.	Very strong.	Strong.
2775	.....do	1 S.	5 E.	22	Dec. 5, 1901	.....	176.2	111.1	42.6	.....	None.	.02	Very strong.	Very strong.	Very strong.
2804	.....do	1 S.	5 E.	23	Jan. 28, 1902	54	103.2	48.8	.....	7.63	.0094	.21	Strong.	Faint.	Faint.
2818	.....do	1 S.	5 E.	22	Mar. 9, 1902	705	157.4	104.0	39.3	.....	Very faint.	.12	Very strong.	Very strong.	Very strong.
2819	.....do	1 S.	5 E.	22	.....do	146	172.2	110.0	45.3	.....	Very faint.	.12	Very strong.	Very strong.	Very strong.
2820	.....do	1 S.	5 E.	22	.....do	236	163.8	104.4	44.5	.....	Very faint.	.12	Very strong.	Very strong.	Very strong.
2977	.....do	1 S.	5 E.	22	Feb. 6, 1903	240	299 6	154.8	20.9	.....	.0105	.29	Very strong.	Strong.	Strong.
2983	.....do	1 S.	5 E.	34	Mar. 7, 1903	260	162.4	80.4	52.2	.....	.0061	.27	Very strong.	Strong.	Very strong.
3157	.....do	1 S.	5 E.	22	June 13, 1903	236	127.4	75.6	23.1	.....	Faint.	.17	Strong.	Faint.	Pronounced.
3158	.....do	1 S.	5 E.	34	.....do	.....	84.8	44.6	18.5	.....	Faint.	.26	Strong.	Faint.	Strong.
3138	Desert well	1 S.	7 E.	11	May 14, 1903	212	32.0	5.2	.....	4.66	Very faint.	.49	Faint.	Very faint.	Faint.
3141	E. Olsen	1 S.	5 E.	18	.....do	212	381.0	235.2	59.8	.....	Faint.	2.0	Very strong.	Strong.	Very strong.
3144	P. Mets	1 N.	5 E.	22	.....do	56	167.8	108.0	.....	9.33	Very faint.	.38	Strong.	Faint.	Strong.
3145	Alhambra Hotel	1 N.	5 E.	22	.....do	51	152.0	89.6	.....	5.51	Very faint.	.33	Strong.	Faint.	Strong.
3146	Dorman Bros	1 N.	6 E.	33	.....do	100	114.0	74.0	.....	.....	.....	.....	Strong.	Very faint.	Strong.
	PHOENIX.														
1819	Fowler Bros	1 N.	1 E.	1	Apr. 30, 1897	.....	399.3	Very strong.	.....	.....	.....	.....	Very strong.	Strong.	Faint.
2017	Mrs. W. J. Murphy	.....	.....	.....	Aug. 15, 1898	.....	334.3	107.0	.....	.....	.05	10.0	34.3	3.64	10.5
2067	North Central Avenue	.....	.....	.....	Sept. 15, 1898	.....	117.7	66.5	.....	.....	None.	.20	.....	.....	.....
2068	School, Central Avenue	1 N.	3 E.	5	.....do	.....	216.1	150.0	.....	.....	.....	.20	.....	.....	.....
2069	Indian School	2 N.	3 E.	20	.....do	15	222.0	141.0	.....	33.36	.0008	Faint.	.....	.....	.....
2070	.....do	2 N.	3 E.	20	.....do	60	362.3	258.0	Strong.	.....	.0028	.30	.....	.....	.....

[illegible]	[illegible] Cawthorn	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2074	Orangewood	2 N.	3 E.	4(?)	do	105	44.9	16.0	Strong.		.0016	.80			
2075	J. A. Wieder	3 N.	3 E.	32	do	146	76.1	31.5	Strong.		.0078	.70			
2076	W. R. Beshier	2 N.	3 E.	20(?)	do	36	126.9	43.0		39.2		.10			
2077	—— Churchill	2 N.	3 E.	20(?)	do	92	284.6	103.0	Strong.		.0004	.80			
2078	do	2 N.	3 E.	20(?)	do	70	531.8	179.5	Strong.		.043	2.10			
2079	M. Morrison	2 N.	3 E.	32(?)	do	28	287.5	203.0	Strong.		.0002	.80			
2080	Wm. Christy	1 N.	2 E.	1	do	22	150.6	84.0	Strong.			.05			
2081	G. R. Brewster	2 N.	2 E.	36	do	35	122.5	44.5		33.63	.0004	.40			
2095	Phoenix city supply	1 N.	3 E.	4	Sept. 18, 1898	42	116.8	72.5	Strong.		.0007	.10			
2840	do	1 N.	3 E.	4	May 9, 1902	42	102.4	54.6	8.98		.0045	.16	Very strong.	Very strong.	Very strong.
3139	do	1 N.	3 E.	4	May 14, 1903	208	132.0	77.6	5.4		Very faint.	.25	Pronounced.	Pronounced.	Strong.
3140	do	1 N.	3 E.	4	do	42	136.0	80.8	6.5		.021	.25	Pronounced.	Pronounced.	Strong.
2143	G. R. Brewster	2 N.	2 E.	36(?)	June 30, 1899		103.4	36.5		34.87	.0006	.02			
2215	Dr. Duffield				Oct. 24, 1899		75.3	35.0		2.3			Strong.	None.	Faint.
2216	do				do		68.8	32.0		4.0					
1612	C. W. Perkins	2 N.	3 E.	23	May 10, 1901	155	83.6	30.8	8.3		.0871	.53	Very strong.	Strong.	Strong.
2625	W. J. Murphy				June 8, 1901		28.2	3.1		2.12			Faint.	Pronounced.	Faint.
2696	do				July 3, 1901		27.6	3.1		2.42	Faint.	.47	Very faint.	Faint.	Faint.
2774	B. Smith				Oct. 14, 1901	25	235.8	153.5	12.10		.0029	.31	Very strong.	Very strong.	Very strong.
2837	Thomas Murphy	2 N.	4 E.	30	Apr. 22, 1902	187	380.4	140.0	10.88		.40	2.33	Very strong.	Very strong.	Very strong.
2838	do	2 N.	4 E.	30	do	168	303.2	136.0	26.65		.80	2.70	Very strong.	Very strong.	Very strong.
2839	do	2 N.	4 E.	30	do	78	388.0	105.0		45.16	.0666	1.43	Very strong.	Very strong.	Very strong.
2842	do	2 N.	4 E.	30	May 9, 1902	325	325.8	123.4	32.1		.0073	.66	Very strong.	Very strong.	Very strong.
2845	J. Miller	2 N.	2 E.	33	May 27, 1902		239.0	89.8					Very strong.	Very strong.	Very strong.
2849	Asylum	1 N.	3 E.	2	June 12, 1902	42	120.4	79.2	8.2		Faint.	Faint.	Very strong.	Very strong.	Very strong.
2949	do	1 N.	3 E.	2	Oct. 31, 1902	90	126.4	78.8	13.6		Very faint.	Very faint.	Very strong.	Strong.	Strong
2960	Soap Springs, 50 miles north				Jan. 5, 1903		272.2	52.4		144.6			Strong.	Faint.	Faint.
2970	A. C. Bartlett	2 N.	3 E.	32	Jan. 2, 1903	60	164.0	102.8	6.8		Faint.	.66	Very strong.	Very strong.	Strong.
2342	J. J. Harris	1 N.	2 E.	6	May 14, 1903	103	268.0	185.0	34.8		Very faint.	2.0	Strong.	Strong.	Very strong.

Chemical analyses of waters in or near Salt River Valley, Arizona—Continued.

Number.	Owner.	Location.			Date.	Depth of well.	Total solids soluble at 110° C.	Chlorine, NaCl (common salt).	Hardness, $CaSO_4$ (sulphate of lime).	Alkalinity, Na_2CO_3 (black alkali).	Nitrogen in the form of nitrites.	Nitrogen in the form of nitrates.	Qualitative.		
		Township.	Range.	Section.									Sulphates.	Magnesia.	Lime.
	PHOENIX—Cont'd.					*Feet.*									
3143	H. Thompson	2 N.	3 E.	8	May 14, 1903	104	26.0	4.0	.....	4.88	0.126	0.33	Faint.	Very faint.	Very faint.
3187	Mission (Presbyterian), Gila Crossing	.....	.....	.....	Aug. 25, 1903	.....	160.0	110.8	28.4	.0	.....	.....	Very strong.	Strong.	Strong.
3184	Lake near Gila Crossing	.....	.....	.....	.....do	.....	107.0	61.2	2.72	.0	.....	.....	Very strong.	Strong.	Strong.
3185	Cooperative ditch, Gila Crossing	.....	.....	.....	.....do	.....	106.0	62.8	13.1	.0	.....	.....	Strong.	Strong.	Strong.
3186	Gila River at Gila Crossing (seepage)	.....	.....	.....	.....do	.....	127.0	76.4	12.5	.0	.....	.....	Very strong.	Strong.	Strong.
3204	S. W. Nigh	2 N.	4 E.	36	Sept. 19, 1903	.....	110.0	60.0	.....	.....	.....	.....	Pronounced.	Very faint.	Pronounced.
3203	N. J. Murphy	2 N.	4 E.	30	.....do	.....	193.0	74.0	.....	.....	.....	.....	Very strong.	Very faint.	Very faint.
3202	—— Underhill	2 N.	4 E.	22	.....do	.....	189.4	93.0	.....	.....	.....	.....	Very strong.	Pronounced.	Strong.
3201	—— Warner	2 N.	4 E.	8	.....do	120	52.0	17.0	.....	.....	.....	.....	Pronounced.	Very faint.	Pronounced.
	Geo. U. Collins	1 N.	2 E.	15	Aug. 25, 1903	29	150.0	94.8	17.40	.0	.....	.....	Strong.	Strong.	Strong.
	L. Kunz	1 N.	3 E.	18	.....do	24	223.0	146.8	53.7	.0	.....	.....	Very strong.	Strong.	Very strong.
	J. Heaton	1 N.	1 W.	15	.....do	45	28.0	5.2	1.09	.0	.....	.....	Pronounced.	Pronounced.	Pronounced.
2092	H. L. Underhill	2 N.	4 E.	22	Sept. 17, 1898	61	84.4	50.0	Strong.	.....	.....	.15	.....	.....	.....
2093	Geo. Blont	2 N.	4 E.	26	.....do	40	159.4	90.0	.....	.....	.....	.40	.....	.....	.....
2795	Winfield Scott	2 N.	4 E.	23	Jan. 9, 1902	67	167.4	100.8	42.7	.....	.001	.50	Very strong.	Very strong.	Very strong.
2796	Paradise Valley	.....	.....	.....	.....do	.....	25.6	5.72	1.6	.....	.0049	.35	Faint.	Pronounced.	Pronounced.
2961	Winfield Scott	2 N.	4 E.	23	Dec. 5, 1902	60	171.4	91.2	21.22	.....	.....	.....	Very strong.	Very strong.	Strong.
	TEMPE.														
1525	J. W. Johnson	1 N.	4 E.	27	Mar. 15, 1897	11	79.2	Strong.	.....	.....	.....	.....	Faint.	.....	.....
2110	Hough's creamery	1 N.	4 E.	23	Dec. 2, 1898	.....	103.0	67.0	Strong.	.....	.....	.....	.....	.....	.....

2111	Hough's ranch				Dec. 2, 1898	8	188.5	109.0	Strong.		.0004	.30			
2113	J. W. Wolf	1 N.	4 E.	23	do	15	160.0	94.0	Strong.		.0012	.20			
2114	J. B. Mullen	1 N.	4 E.	35	do	13	287.6	192.0	Strong.		.0004	.25			
2115	W. T. Fowler				do	12	163.1	88.5		26.82	.0028	.30			
2116	Niels Peterson	1 N.	4 E.	29	do	20	221.8	141.5		24.91	.0004	.20			
2118	A. P. McKern	1 N.	3 E.	6	do		171.5	110.0	6.8		.0004	.05			
2303	Wolf & Jones				Mar. 28, 1900		128.8	80.8	12.0		.0006	.30			
2304	do				do		190.4	120.0	6.1			.25			
2339	Hotel Casa Loma	1 N.	4 E.	15	May 7, 1900		169.8	105.8	12.9		.0027	.18	Very strong.	Pronounced.	Very strong.
2748	Geo. Kinney				Oct. 17, 1901	40	202.6	130.5	8.16		None.	.25	Strong.	Very strong.	Strong.
2766	Normal School	1 N.	4 E.	22	Nov. 19, 1901	30	219.2	133.6	15.78		None.	.51	Very strong.	Very strong.	Very strong.
2966	A. R. Jenkins	1 N.	4 E.	19	Jan. 2, 1903	50	217.0	142.4		3.6	.004	.20	Very strong.	Strong.	Strong.
2967	do	1 N.	4 E.	19	do	50	223.0	171.2		3.4			Very strong.	Strong.	Strong.
2968	A. J. Hansen	1 S.	4 E.	35	do	156	509.0	355.0	60.9				Very strong.	Very strong.	Very strong.
2980	do	1 S.	4 E.	35	do	156	446.8	307.0	135.4		Faint.	Faint.	Very strong.	Very strong.	Very strong.
2969	H. L. Chandler	1 N.	4 E.	21	do	180	224.0	146.0		2.12			Very strong.	Very strong.	Strong.
2973	Tempe city supply				Jan. 8, 1903	200	103.0	58.8	9.52		None.	.17	Strong.	Strong.	Strong.
3118	Valley Seedless Grape Co	1 S.	4 E.	4	Mar. 19, 1903	200	115.2	78.6	11.4				Strong.	Pronounced.	Strong.
3119	do	1 S.	4 E.	4	do	300	155.8	105.4	21.8				Strong.	Pronounced.	Strong.
2226	Salt River				Nov. 17, 1899		134.5	81.8			.04	.10			
2251	A. R. Jenkins ditch	1 N.	4 E.	20	Dec. 26, 1899		189.4	136.0		8.4			Very strong.	Strong.	Very strong.
2252	do	1 N.	4 E.	20	do		216.4	142.9		7.7			Strong.	Strong.	Strong.
2285	Buckeye canal				Mar. 5, 1900		182.0	119.2	23.1		.0032	.126	Very strong.	Strong.	Very strong.
2286	Richardson ditch	1 N.	1 W.	(?)	do		30.0	6.0		1.17	.004	.16	Strong.	Strong.	Strong.
2340	do	1 N.	1 W.	(?)	May 21, 1900		33.4	7.4		1.3	Faint.	.148	Strong.	Strong.	Strong.
2287	Salt River seepage, Phoenix				Mar. 5, 1900		130.0	86.4		.32	.0064	.30	Strong.	Strong.	Very strong.
2288	Salt River at Tempe				Mar. 5, 1900		118.0	79.6	10.2		.008	.22	Strong.	Strong.	Very strong.
2289	Salt River at Arizona dam				do		102.2	68.4		.62		.20	Strong.	Strong.	Strong.
2293	Agua Fria underflow, Buckeye				Mar. 6, 1900		78.4	32.2		1.50	Faint.	.08			
2341	Buckeye canal				May 21, 1900		185.0	121.8	23.4		Faint.	.165	Very strong.	Very strong.	Very strong.
	Lewis Wetzler	1 N.	3 E.	11	Sept. 19, 1903	40	144.0	86.0	23.9	0.0			Pronounced.	Very faint.	Strong.

Chemical analyses of waters in or near Salt River Valley, Arizona—Continued.

Number.	Owner.	Location.			Date.	Depth of well.	Total solids soluble at 110° C.	Chlorine, NaCl (common salt).	Hardness, $CaSO_4$ (sulphate of lime).	Alkalinity, Na_2CO_3 (black alkali).	Nitrogen in the form of nitrites.	Nitrogen in the form of nitrates.	Qualitative.		
		Township.	Range.	Section.									Sulphates.	Magnesia.	Lime.
	TEMPE—Cont'd.					*Feet.*									
3154	C. T. Sharp, Sacaton				May 20, 1903	30	132.6	66.8	29.4	.....	0.031	0.083	Very strong.	Strong.	Very strong.
3156	Beet-sugar factory	2 N.	2 E.	8	June 10, 1903	112	54.6	15.6	0.0	1.99	.08	1.24	Pronounced.	Faint.	Pronounced.
3236	Ostrich ranch	1 N.	1 E.	3	Feb. 16, 1904	170	130.0	76.0	8.2	0.00	.....	.....	Very strong.	Distinct.	Strong.
3230	Bartlett-Heard	1 N.	4 E.	30	Feb. 4, 1904	100	194.0	126.0	5.44	0.0	0.0	0.0	Strong.	Strong.	Strong.
3237	D. B. Heard				Feb. 16, 1904	.....	185.0	111.6	13.6	0.0	.....	.....	Strong.	Strong.	Very strong.
3238	Bristol Flummerfelt	1 S.	4 E.	11	.....do.....	61	186.0	122.0	13.6	0.0	.....	.....	Strong.	Strong.	Very strong.
3239	Robert Bowen	2 S.	9 E.	(?)	.....do.....	212	54.0	24.0	16.3	0.0	.....	.....	Distinct.	Distinct.	Strong.

Analyses of waters from Salt River Valley.[a]

[Parts in 100,000.]

Owner of well.	Location. Township.	Range.	Section.	Depth of well.	Total salts in solution.	Calcium sulphate.	Calcium and magnesium carbonates.	Chlorine reckoned as common salt.	Sodium carbonate.	Sodium nitrate.	Qualitative.
				Feet.							
Phoenix city supply	1 N.	3 E.	4	42	116.8	1.0	22.0	72.0	.....	1.0	Magnesium sulphate.
A. P. McKern	1 N.	3 E.	6	.....	171.46	1.3	32.65	110.0	.....	.06	Magnesium chloride and sulphate.
—— Thomas	.....	.....	.....	30	117.65	1.35	14.60	66.5	.....	.2	Do.
School building	1 N.	3 E.	5	.....	216 10	5.60	23.05	150.0	Trace.	.2	Magnesium sulphate.
Indian School	2 N.	3 E.	20	15	222.0	.....	26.65	141.0	33.36	.....	Sodium, magnesium, and potassium sulphates.
Do	2 N.	3 E.	20	60	362.25	29.95	27.45	258.0	.....	.3	Calcium chloride, magnesium chloride and sulphate.
Well south of W. S. Lawrence's places.	.....	.....	.....	30	413.10	5.45	47.75	285.0	.....	.6	Magnesium chloride and sulphate.
Well at middle one of W. S Lawrence's places	....	.....	.....	24	370.80	.....	22.15	176.5	23.59	.3	Sodium and potassium sulphates.
—— Cawthorn	2 N.	3 E	29(?)	65	97.60	1.60	11.35	61.0	.....	.4	Sodium and magnesium sulphates.
—— Blaine	2 N.	3 E.	4(?)	105	44.90	1.85	5.35	16.0	.....	.8	Magnesium sulphate.
J. A. Wieder	3 N.	3 E.	32	146	76.1	1.20	15.75	31.5	.....	.7	Calcium chloride. magnesium chloride and sulphate.
—— Beshier	2 N.	3 E.	20(?)	36	126.90	.26	5.05	43.0	39.22	.1	Sodium and potassium sulphates.
—— Churchill	2 N.	3 E.	20(?)	92	284.60	7.15	21.10	103.0	.....	.8	Magnesium sulphate.
M. Morrison	2 N.	3 E	32(?)	28	287.50	19.30	16.65	203.0	.....	.8	Calcium chloride, magnesium chloride and sulphate.
Col. Wm. Christy	1 N.	2 E.	1	22	150.60	2.65	20.45	84.0	.....	.05	Magnesium sulphate.
G. R. Brewster	2 N.	2 E.	36	35	122.46	.21	10.60	44.5	33.63	.4	Sodium and potassium sulphates.
Blacksmith shop	2 N.	2 E.	26	50	116.30	.22	9.15	56.0	34.13	.05	Do.
A. H. Smith	2 N.	2 E.	21	95	130.50	6.8	11.65	40.0	.....	10.0	Calcium chloride, magnesium chloride and sulphate.
Frank Alkire	2 N.	2 E.	21	96	41.10	2.2	8.7	10.0	.....	1.5	Magnesium chloride and sulphate.
—— Barclay	2 N.	2 E.	17	90	340.80	56.90	12.25	68.0	.....	16.0	Do.

[a] McClatchie, Alfred J., and Forbes, Robert H., Ariz. Agric. Exp. Station, Bull. 30, 1899.

Analyses of water from Salt River Valley—Continued.

Owner of well.	Location.			Depth of well.	Total salts in solution.	Calcium sulphate.	Calcium and magnesium carbonates.	Chlorine reckoned as common salt.	Sodium carbonate.	Sodium nitrate.	Qualitative.
	Township.	Range.	Section.								
				Feet.							
—— Boyer	2 N.	2 E.	18(?)	80	234.45	21.30	10.85	149.0	.....	0.6	Calcium and magnesium chlorides.
W. S. McClain	2 N.	2 E.	18	80	117.55	1.2	11.75	29.0	.....	7.0	Sodium and magnesium sulphates.
Glendale town well	2 N.	2 E.	5	90	79.2	2.8	20.0	39.0	.....	.....	Sodium sulphate, magnesium chloride and sulphate.
—— Bartlett	3 N.	2 E.	30	140	53.05	2.0	6.95	17.0	.....	.8	Magnesium chloride and sulphate.
—— Mosher	2 N.	1 E.	9	70	346.40	111.50	13.85	112.0	.....	1.0	Sodium and magnesium sulphates.
J. B. Morgan	2 N.	1 E.	5	40	46.20	1.45	15.75	10.0	.....	.4	Do.
H. L. Underhill	2 N.	4 E.	22	61	84.4	1.55	12.80	50.0	.....	.15	Magnesium chloride and sulphate.
George Blount	2 N.	4 E.	26	40	159.35	20.90	22.40	90.0	.....	.4	Sodium and magnesium sulphates.
Arizona Falls canal water, taken Sept. 17, 1898.	.....	.....	.....	.....	93.30	1.0	13.60	61.5	.....	.....	Do.
Arizona Falls water taken Jan. 5 to Jan. 31, 1897.	.....	.....	.....	.....	46.4	.....	16.3	17.0	.....	.....	
F. A. Hough	1 N.	4 E.	23	22	103.03	.9	16.35	67.0	.....	.....	Magnesium chloride and sulphate.
J. W. Woolf	1 N.	4 E.	23	15	159.96	1.90	32.90	94.0	.....	.2	Magnesium sulphate.
J. B. Mullen	1 N.	4 E.	35	13	287.56	4.0	40.45	192.0	.....	.25	Magnesium chloride and sulphate.
W. T. Trusler	1 N.	4 E.	27	12	163.10	.43	12.0	88.5	26.82	.3	Sodium and potassium sulphates.
Nels Peterson	1 N.	4 E.	29	20	221.80	.66	15.30	141.5	24.91	.2	Do.
Canaigre ranch, 6 miles southeast of Phoenix.	.....	.....	.....	34	171.40	1.60	29.05	108.5	.....	.2	Magnesium chloride and sulphate.

Analyses of waters in Salt River Valley by electrical method.

[Data furnished by Thos. H. Means.]

Source of sample.	Location.	Depth to water.	Parts of Na_2CO_3 in 100,000.	Parts of solids in 100,000.
		Feet.		
Tempe ditch	1 mile south of Tempe			105
Jenkins ditch	¼ mile east of Bell Butte			209
Do	do		5.8	195
Do	do			211
Well	Sec. 33, T. 1 N., R. 4 E., just below canal			258
Canal	do			115
Well	Sec. 3, T. 1 S., R. 4 E., ¼ mile south of date orchard			251
Do	Sec. 27, T. 1 S., R. 4 E., Harmon's place	5	10.5	160
Do	Sec. 19, T. 1 N., R. 4 E., Reed's place	16		265
Do	Sec. 27, NE. ¼ NE. ¼, T. 1 N., R. 4 E., Rice place	9		209
Do	Sec. 35, SE. ¼ SW ¼, T. 1 S., R. 4 E.	(a)		167
Canal	do			111
Well	Sec. 24, SE. ¼ SW. ¼, T. 1 N., R. 5 E.	11		179
Do	Sec. 19, NE. ¼ SE. ¼, T. 1 N., R. 5 E.	30		161
Do	Sec. 2, NW. corner, T. 1 S., R. 5 E.	15		213
Canal	Sec. 36, T. 1 N., R. 5 E., Consolidated canal			99
Well	Sec. 12, NE. corner, T. 1 S., R. 5 E	50		436
Do	Pumping plant below Highland canal, east of Mesa	60		92
Springs	Sec. 13, T. 1 N., R. 4 E., springs along Salt River seeping from gravel.			167
Salt River	Sec. 13, T. 1 N., R. 4 E.			152
Do	At Tempe Bridge			123
Well	Sec. 13, NE. ¼ NW. ¼, T. 1 N., R. 4 E.	12		189
Salt River	Above intake of Tempe canal			113
Well	Sec. 9, SW. ¼ SW. ¼, T. 1 N., R. 4 E	13		158
Ditch	Sec. 23, T. 1 N., R. 3 E., south side			150
Salt River	Southwest of Phoenix			135
Well	Sec. 6, SW. corner, T. 1 S., R. 6 E	40		184
Do	Sec. 9, SW. ¼ SW. ¼, T. 1 N., R. 3 E., brickyard	12		179
Salt River	Sec. 19, SW. corner, T. 1 N., R. 2 E.			131
Canal	St. Johns canal, meridian line			144
Well	Sec. 9, T. 1 N., R. 3 E., south of S. P. depot			177
Do	T. 1 N., R. 1 E.			305
Do	Sec. 13, NW. ¼ SW. ¼, T. 1 N., R. 1 E.			277
Draw	Emptying into Gila River 2 miles above Agua Fria			258
Gila River	At initial monument			169
Canal	St. Johns canal			159
Well	¼ mile north of initial monument			213
Gila River	¼ mile west of initial monument			158

[a] Rises to surface.

ORIGIN OF SALTS.

SALTS IN WELL WATER.

An inspection of the chemical analyses of well waters and a comparison of them with analyses of the river water given below reveals a remarkable similarity in the salt content. Since the débris contributed by Salt River is the principal source of the valley fill, we naturally look to Salt River as the source of the salts found in the sediment. The accompanying table by Professor Forbes[a] indicates the character

[a] Forbes, R. H., The river irrigating waters of Arizona: University of Arizona Agric. Exp. Sta. Bull. No. 44, 1902, p. 174.

of Salt River water. The salts of the valley fill are regarded as concentrations by evaporation from the river waters. A study of the conditions as they exist in and near the river bed at the present time throws some light upon the manner of concentration.

Composition of the waters of Salt River.

[Samples taken at the Consolidated Canal Company's office, Mesa, Ariz., representing the Arizona Canal dam supply.]

PARTIAL ANALYSES.

	High and low summer waters (average of 4 weekly composites of samples taken daily, Aug. 1–Sept. 1, 1899).	Summer flood water (one weekly composite of daily samples taken Sept. 2–9, 1899).	High and low summer waters (average of 4 weekly composites of daily samples taken Sept. 10–Oct. 9, 1899).	Winter flood water (one composite of daily samples taken Oct. 10–17, 1899).	Low winter water (average of 10 weekly composites of daily samples taken Oct. 18–Dec. 30, 1899).	Low winter water (average of 13 weekly composites of daily samples taken Feb. 17–May 30, 1900).	Very low summer water (average of 8 weekly composites of daily samples taken June 1–Aug. 4, 1900.
Silt, per cent by weight	0.32	0.95	0.086	0.714	0.025	0.024	0.026
Soluble solids, parts in 100,000	72.40	110.00	114.20	95.10	102.64	106.90	139.15
Containing chlorine stated as common salt, NaCl	46.2	52.1	72.9	61.9	67.6	72.2	98.1
Containing alkalinity stated as sodium carbonate, Na_2CO_3	.....	1.80	.....	.....	.....	.....	.....
Containing permanent hardness stated as calcium sulphate, $CaSO_4$	1.59	.....	2.79	2.45	2.12	5.43	13.70
Nitrogen, parts in 1,000,000:							
Total nitrogen in silt and water	6.94	26.7	4.36	12.19	4.96	1.48	1.30
Nitrogen in nitrates	1.32	1.2	1.90	1.52	1.21	.67	.78
Nitrogen in nitrites	Traces nearly always.						

COMPLETE ANALYSES OF SOLUBLE SALTS, STATED BY IONS.

[Parts in 100,000 of water.]

Sodium, Na	12.2	18.3	27.45	.....	30.99	32.7	40.73
Potassium, K	1.29	1.41	1.09	.....	1.53	1.23	1.12
Calcium, Ca	6.79	10.2	7.24	.....	4.02	4.37	6.51
Magnesium, Mg	1.74	2.33	2.79	.....	2.84	2.92	3.28
Chlorine, Cl	27.99	31.57	44.11	.....	40.96	43.75	59.44
Sulphuric, SO_4	9.79	4.81	7.27	.....	7.48	7.64	9.19
Carbonic, CO_3	.....	15.45	8.02	.....	11.71	11.51	13.15
Silicic, SiO_3	2.06	1.11	5.83	.....	4.65	5.29	3.55

COMPLETE ANALYSES OF SOLUBLE SALTS CALCULATED TO COMPOUNDS.

[Parts in 100,000 of water.]

Sodium silicate, Na_2SiO_3	3.31	1.79	9.35	.....	7.46	8.50	5.69
Sodium chloride, NaCl	27.84	42.80	60.84	.....	67.54	72.16	98.04
Sodium sulphate, Na_2SO_4	.....	.....	.....	.....	4.97	3.46	.07
Sodium carbonate, Na_2CO_3	.....	1.80	.....	.....	.....	.....	.....
Potassium chloride, KCl	2.45	2.69	2.07	.....	.....	.....	.....
Potassium sulphate, K_2SO_4	.....	.....	.....	.....	3.40	2.74	2.50
Magnesium chloride, $MgCl_2$	6.88	5.81	8.34	.....	.....	.....	.....
Magnesium carbonate, $MgCO_3$	.....	3.03	2.37	.....	9.93	10.21	11.49
Calcium chloride, $CaCl_2$	7.50	.....	.....	.....	.....	.....	.....
Calcium sulphate, $CaSO_4$	13.87	6.82	10.30	.....	3.18	5.37	11.00
Calcium carbonate, $CaCO_3$	.....	20.48	10.53	.....	7.71	7.00	8.20

In certain localities along the river the surface of the underground water is so near the land surface that evaporation takes place readily. Water from the river directly or from the underflow is continually finding its way into these localities, bearing its burden of soluble salts, and escaping from the surface by evaporation, leaving its load of salts behind. Localities which have been thus affected are found near Tempe (Pl. XXIII, *A*) and in many places in Gila Valley. Floods may remove these deposits of salt or may bury them, according to circumstances. At the present time both results are being accomplished. The constant shifting of the river channel causes a corresponding shifting of degradational and aggradational localities. Where the aggradational processes predominate, a notable amount of the accumulated salts are necessarily buried.

SALTS IN RIVER WATER.

The origin of the salts contained in the river water presents a different problem. It has recently been demonstrated by M. O. Leighton and his assistant, Sheldon Baker,[a] of the United States Geological Survey, that the common salt so abundant in Salt River is probably due to large salt springs. Several springs were found along the upper reaches of Salt River whose water is described as a weak brine. The water is also strong in carbonates, as evidenced by large travertine deposits at the point of issuance. Iron is also abundant in the water and is deposited near the springs as red oxide. The carbonates contained in the waters are probably due in part to the limestones drained by Salt River and its tributaries and in part to the decomposition of the granitic rocks in its basin. The sodium carbonate, or "black alkali," seems to be due to the decomposition of the igneous rocks. It will be noted that the river water is ordinarily lacking in black alkali, but that it is contained occasionally in flood waters. It is the belief that this is due to the fall of rain upon some alkali-charged slope or mesa which is seldom visited by rains in sufficient quantity to carry away the soluble salts. Specific examples are given by Professor Forbes[b] as follows:

> For the period from September 2 to 17, during which a flood occurred, the salts were greater than in the low water preceding and following. The alkali in this water was also distinctly black in character. These circumstances indicate that this flood, which was due to heavy rainfall on the lower half of the Verde River, washed large surface accumulations of salts from a black-alkaline district into the drainage. To a less degree the same holds true of the small flood from August 16 to 22. In most instances, however, during flood time the soluble salts more or less abruptly decrease oppositely to increasing sediments. Mountain rainfall such as was that of August and October, 1899, and May, 1900, is evidently responsible for this freshening of the water. Mountain rainfall in southern Arizona is more abundant than upon the level, lower deserts. The higher watersheds, being better drained, afford

[a] Personal communication.

[b] Forbes, R. H., op. cit, p. 165.

fresher water. The less frequent, though often copious, floods which sweep the lower levels carry much accumulated soluble salt into the drainage, which is often thus rendered strongly saline.

EFFECT OF SALTS ON VEGETATION.

EFFECT IN ARIZONA.

There is a widespread opinion among water users of Salt River Valley that the waters of the underflow are injurious to vegetation. The evidence on this question is conflicting. It is probable that too little is known of determining conditions in Salt River Valley to draw any general conclusion at the present time. The character of the soil, the manner of manipulation, and the kind of crop should be considered as well as the character of the water. Professor Forbes[a] has studied this question and concludes that waters containing more than 100 parts of soluble salts in 100,000 parts of water "are liable in a few years to cause harmful accumulations of alkali."

On the other hand there are many instances of land irrigated with pumped water alone where no detrimental effects can be detected. The Collins well has supplied land entirely with irrigation water containing 150 parts of soluble salts in 100,000 parts of water, for several years, with no detrimental effect that can be detected. Doctor Kunz's garden has had no water for five years other than well water containing 223 parts of salts. The court-house yard in Phoenix has been irrigated for about twenty years with well water alone, containing from 102 to 136 parts of salts. The Indians at the western end of the Pima Reservation have used the seepage water from Salt River, containing about 200 parts of salts, for many years. Land upon which this water has been used continuously at least since the Indians came under the supervision of the white men, about thirty years ago, is at the present time the most productive land on the reservation.

The sodium carbonate (black alkali) is the salt most feared by those who object to the use of pumped water. It will be noted from an inspection of the tables that no sodium carbonate is found in the underflow from which the great proportion of the pumped water is to be secured. The sodium carbonate is found only in the comparatively unimportant surface waters in the Mesa region and in the Phoenix region and is north of the area in which irrigation waters can probably be pumped with profit. It is evident, therefore, that the quantity of this salt which would probably find its way into waters pumped for irrigation is too small to be seriously considered.

The effects of accumulation of salts in the soil is plainly marked in certain parts of the valley. A considerable part of the land south of Tempe is barren in places and covered with white incrustations of salt

[a] Forbes, R. H., op. cit., p. 166.

A. AN ORCHARD NEAR PHOENIX KILLED BY LACK OF WATER.

B. DESERT NEAR TEMPE, SHOWING TYPICAL DESERT VEGETATION.

(Pl. XXIII, *A*). Some of this land has been under cultivation, and has been abandoned on account of the accumulations of alkali. It is in this region that the Bureau of Soils has leased a tract of land for the purpose of demonstrating the methods of reclaiming alkali land.

EFFECT IN EGYPT.

Waters much more saline than those of Salt River Valley may be used for irrigation if used properly, as is shown by the following extract from a circular by Mr. Means:[a]

During the summer of 1902 a representative of the Bureau of Soils visited the oases of the Oued Rihr country in the Desert of Sahara in eastern Algeria. In these oases artesian waters carrying very large quantities of soluble matter are used successfully for irrigation. From the information gathered there, and from experience in this country, it seems that the amount of soluble matter allowable in an irrigation water has been greatly underestimated by American writers, and that many sources of water which have been condemned can be used with safety and success, provided the proper precautions are taken to prevent the accumulation of the salts. As the precautions are those which should be taken by every irrigator, even if pure water is used, it seems an important matter to bring before the American people the methods in use in the Sahara.

The staple crop grown by the Arabs in the oasis country is the date, the fruit of a palm tree known to be one of the plants most resistant to alkaline or saline conditions of the soil, but in addition to this considerable quantities of the deciduous fruits, garden vegetables, and alfalfa are produced for home consumption.

Some of the vegetables successfully grown are those considered sensitive to alkali, and yet they were being irrigated with water containing in some instances as much as 800 parts of soluble salts to 100,000 parts of water, sometimes as high as 50 per cent of the salts being sodium chloride.

The limit of concentration for irrigation water in the United States, even where only the most resistant field crops are to be grown, has been placed by some authorities at 30 parts sodium chloride (common salt) or sodium carbonate (black alkali), and at from 170 to 300 parts of the less harmful salts, per 100,000 of water.

* * * * * * *

The fact that the Arabs in Algerian oases are actually growing sensitive plants by the aid of irrigation waters containing from 400 to 800 parts of soluble salts, in some instances 50 per cent sodium chloride, shows that the Bureau has been on the conservative side in its estimates and should encourage a more hopeful feeling among the people occupying areas where only alkali water is available for irrigation.

The prerequisite to the use of water of high salt content in irrigation is the knowledge that the methods employed are opposed to the teachings of most American writers on the subject. Those who place the low limit of safety for alkaline irrigation waters have taught that where water was badly alkaline irrigation should be sparing. They have not insisted on thorough drainage, and they have warned irrigators against too frequent irrigation. With such practices the limit of concentration which they set is probably high enough, and even then all except the most sandy soils or those with exceptionally good natural drainage would ultimately be damaged.

The methods in the oases are quite different. The Arab gardens are divided into small plats, about 200 feet square, between which run drainage ditches dug to a depth of about 3 feet. The soils being very light and sandy, this ditching at short intervals

[a] Means, T. H., The use of alkaline and saline waters for irrigation: Bur. Soils Circular No. 10, U. S. Dept. Agric., 1903.

insures the most rapid and thorough drainage. Irrigation is by the check method, and application is made at least once a week, though often two wettings a week are deemed necessary. A large quantity of water is used at each irrigation. Thus a continuous movement of the water downward is maintained, and there is little opportunity for the soil water to become more concentrated than the water as applied, and the interval between irrigations being so short but little accumulation of salt from evaporation at the surface takes place. What concentration or accumulation does occur is quickly corrected by the succeeding irrigation.

The native gardens are situated in the date palm groves and the vegetables and fruit are grown in the partial shade cast by these trees. The natives not only have the question of very saline irrigation waters to contend with, but the soils originally are often very alkaline. In three years they reclaim land too salty to grow the minor crops, using the saline water for that purpose, following the same plan of drainage and weekly irrigation as where crops are growing. One garden situated on the side of a salt flat and originally very saline was visited. Here alfalfa was in very good condition, and fig, pomegranate, melon, tomato, cabbage, pepper, and other plants were growing luxuriantly. The reclamation of this plat by irrigation twice a week had taken three years.

* * * * * * *

The irrigation water is all drawn from artesian wells. A number of samples were sent in to the laboratory for analysis, the results of which are shown in the following table. These are fair average samples of the irrigation waters in use, and do not represent by any means the maximum of salinity. Field tests showed as high as 816 parts to 100,000 of water in actual use on soils growing vegetables.

Chemical analyses of artesian water used in irrigating gardens in Sahara oases, Algeria.

Constituent.	Well at oasis Tabessbest.	Well at oasis Kudi Asli.	Well at garden of Ben Hadrian.
Ions:	*Per cent.*	*Per cent.*	*Per cent.*
Calcium (Ca)	9.92	4.19	9.86
Magnesium (Mg)	4.52	6.02	4.26
Sodium (Na)	14.03	20.48	14.18
Potassium (K)	4.27	2.35	2.72
Sulphuric acid (SO_4)	34.38	29.43	17.59
Chlorine (Cl)	28.06	36.21	27.05
Bicarbonic acid (HCO_3)	5.02	1.32	24.34
Conventional combinations:			
Calcium sulphate ($CaSO_4$)	33.04	14.23	24.90
Magnesium sulphate ($MgSO_4$)	13.63	24.29	7.04
Magnesium chloride ($MgCl_2$)	7.23	4.41	16.72
Potassium chloride (KCl)	8.12	4.48	5.19
Sodium bicarbonate ($NaHCO_3$)	6.92	1.81	33.54
Sodium chloride (NaCl)	31.06	50.78	12.61
Total solids in 100,000 parts water	601.50	408.10	571.90

A. SEEPAGE LAND SOUTHEAST OF TEMPE.

B. VIEW SOUTHWARD FROM TEMPE BUTTE.

QUANTITY OF UNDERGROUND WATER.

THE UNDERFLOW.

WATER ENTERING THE VALLEY.

In order to secure a measure of the water entering the valley fill as underflow, it would be necessary to measure all streams, both permanent and intermittent, as well as the occasional waters entering as sheet wash from the surrounding hills. It would be necessary, furthermore, to measure the quantity of surface water escaping from the valley. The greater part of the supply is from Salt River and the total quantity entering from this source is known from the records of the gaging stations on Salt and Verde rivers. The amount taken from the river by the canals is known, but the loss from the valley during times of flood is unknown on account of the want of a gaging station at the outlet of the valley. It is, therefore, obviously impossible to arrive in this way at even an approximate measure of the water entering the underflow. Other methods must be resorted to in order to obtain a quantitative estimate.

RETURN WATER.

The Tempe canal diverts all the surface water of the river north of Mesa. Near Tempe the underground water returns to the surface, making a flow of about 35 second-feet. West of Phoenix the underground water again returns to the surface. It is not possible at present, however, to state what proportion of the seepage water comes from Salt River, since its underflow joins that from Gila River. It is probable, however, as previously stated, that the underflow of the Gila is fed in large measure by the waters from Salt River passing as underflow east of Salt River Mountains. In Gila Valley west of Florence all the waters diverted from the river, except during occasional floods, are seepage waters. The flow in the Gila channel and in the Indian ditches at Gila Crossing was 800 inches when measured on August 17, 1902. Mr. M. M. Murphy estimated the water diverted by the Indian ditches east of the junction of Gila and Salt rivers in January, 1903, as 500 inches, leaving 1,000 inches in the river. The smaller canals of Salt River, between Tempe and the Buckeye, divert water as follows:

Water received by canals west of Phoenix, Ariz.

[Information furnished by M. M. Murphy.]

Canal.	June, 1902.	June, 1903.
	Inches.	*Inches.*
Leon	265	None.
Peninsula	35	23
Lambeye	74	13
Meridian	153	13
Indian	82	7
Total	609	52

The winter flow is about double the above. Available summer flow at the head of St. Johns canal is 400 inches.

Maximum winter flow (not flood) at St. Johns is 800 inches.

Indian ditches on the lower Gila take a minimum of 400 inches.

The amount taken by the Salt River and Maricopa canals—join at head—for June, 1903, averaged 1,344 inches. This is slightly more than usual.

The amount diverted by the Buckeye canal is given by Mr. W. A. Apgar, as follows:

Flow in Buckeye canal.

	Second-feet.
July, 1902	78
July, 1902[a]	80
May 14, 1903	129
May 23, 1903	133
May 24, 1903	128

Davis[b] says:

The amount of seepage water was measured by Mr. Cyrus C. Babb in June, 1896, and the results showed in one case an increase of over 80 second-feet in a distance of 7 miles.

Code[c] states that "the return flow picked up by the head of the Maricopa and Salt River canals in ordinary years is found to approximate 60 cubic feet per second. This flow has naturally decreased during the past summer owing to the scanty irrigations received by the Mesa, Utah, and Tempe lands above, and to the gradual lowering of the underground supply." He states further that—

at the head of the Buckeye canal, some 24 miles farther down the stream, is again found a volume approximating in ordinary summers 150 cubic feet per second. * * * Some 20 miles below the Buckeye, I am told, another flow of approximately 50 cubic feet per second is to be picked up.

[a] A few days later.

[b] Davis, A. P., Irrigation near Phoenix, Ariz.: Water-Sup. and Irr. Paper No. 2, U. S. Geol. Survey, 1897, p. 43.

[c] Code, W. H., Irrigation in Salt River Valley, in Report of irrigation investigations for 1900, No. 2: U. S. Dept. Agric., Bull. 104, 1901, p. 103.

According to Code's estimate the return water is 210 second-feet, whereas the estimate given above is only 150.

There is no time for which measurements are available for all the canals diverting seepage water. The amount, however, of the seepage water does not vary to any great extent. The average amount, then, according to the best measurements and estimates available is something over 150 second-feet, making a total of more than 100,000 acre-feet per year.

If Code's estimate be accepted the return water east of the Buckeye canal is something over 150,000 acre-feet per year. A small part of this is return water from irrigated lands, but the greater part is from the natural underground flow. A considerable but undetermined part of it is from the Gila underflow, but the greater part is from Salt River.

The seepage waters estimated at 100,000 acre-feet per year are only those returning to the surface east of the Buckeye canal, and take no account of a large quantity of return water diverted by the several canals farther down the river. Furthermore no account is taken of the quantity passing as underflow through the gravels at the lower end of the valley, at the Buckeye head-gates. The 100,000 acre-feet is a measure of the spill from the top of the underflow—water which the valley fill for some reason is unable to hold. The total volume of underflow is therefore something greater than 100,000 acre-feet per year.

MEASURING THE UNDERFLOW.

SLICHTER'S METHOD.

The most elaborate and scientific method of arriving at a quantitative estimate of the underground waters of the valley is obtained from the application of Slichter's[a] method. On account of the great importance of arriving at as accurate an understanding as possible of the underflow and its probable volume, I quote from this paper such portions as apply to the principles and methods of procedure. After a discussion of the principles relating to the movement of underground waters, Professor Slichter proceeds:

Formula.—The formula which the writer has devised for determining the flow of water through a column of sand is as follows:

$$q = 0.2012 \frac{\rho d^2 s}{\mu h K} \text{ cubic feet per minute.} \quad (3)$$

In this formula q stands for the quantity of water transmitted by the column of sand in one minute; ρ is the difference in pressure at the ends of the columns, or the head under which the flow takes place, measured in feet of water; s is the area of the cross section of the sand column, measured in square feet; h is the length of

[a] Slichter, Charles S., The motions of underground waters: Water-Sup. and Irr. Paper No. 67, U. S. Geol. Survey, 1902, pp. 24-30.

the column, in feet; d is the mean diameter of the soil grains, measured in millimeters, or the so-called "effective size;" μ is the number which takes account of the friction between the particles of water, and is known as the coefficient of viscosity (it is defined as the amount of force necessary to maintain unit difference in velocity between two layers of water unit distance apart; its value, which decreases rapidly with an increase in the temperature of water, for temperatures from 32° to 100° is given in the table below); K is a constant which depends upon the porosity of the sand, and its value for porosities, varying from 26 to 47 per cent, has been computed and is given in the table, page 155.

Variations of the viscosity of water with temperature, and the relative flow[a] of water of various temperatures through a soil, 50° F. being taken as the standard temperature

Temperature.	Coefficient of viscosity μ.	Relative flow.[a]
°F.		
32	0.0178	0.74
35	.0168	.78
40	.0154	.85
45	.0142	.92
50	.0131	1.00
55	.0121	1.08
60	.0113	1.16
65	.0105	1.25
70	.0098	1.34
75	.0092	1.42
80	.0087	1.51
85	.0081	1.62
90	.0077	1.70
95	.0073	1.80
100	.0069	1.90

[a] "Relative flow" means flow at a given temperature compared with flow at 50° F. It is expressed as a percentage.

Constants for various porosities of an ideal soil.

Porosity m.	$\frac{1}{K}$	Log. K.	Diff.	Colog. K.
Per cent.				
0.26	0.01187	1.9258	563	8.0742
.27	.01350	1.8695	504	8.1305
.28	.01517	1.8191	490	8.1809
.29	.01694	1.7701	502	8.2299
.30	.01905	1.7199	467	8.2801
.31	.02122	1.6732	455	8.3268
.32	.02356	1.6277	430	8.3723
.33	.02601	1.5847	438	8.4152
.34	.02878	1.5409	410	8.4591
.35	.03163	1.4999	407	8.5001
.36	.03473	1.4592	400	8.5408
.37	.03808	1.4193	377	8.5807
.38	.04154	1.3816	371	8.6184
.39	.04524	1.3445	367	8.6555
.40	.04922	1.3078	353	8.6922
.41	.05339	1.2725	351	8.7275
.42	.05789	1.2374	345	8.7626
.43	.06267	1.2029	339	8.7971
.44	.06776	1.1690	320	8.8310
.45	.07295	1.1370	312	8.8630
.46	.07838	1.1058	329	8.8942
.47	.08455	1.0729	.....	8.9271

If t stands for temperature of the water F., the author's formula, in which t coefficient of viscosity has been replaced by an expression varying with the temp ature similar to that given in the formula of Hazen, may be written as follows:

$$q=11.3\,\frac{pd^2s}{hK}\,[1+0.0187\,(t-32)]\text{ cubic feet per minute.}$$

It is seen from the above formula that the quantity of water transmitted b column of sand not only depends upon the length of the column and the head water as expressed by Darcy's law, but varies in a most remarkable way with effective size of the soil grain, with the temperature of the water, and with porosity. Since the flow varies as the square of the size of the soil grain, this ment in the formula has a most important effect, as doubling the size of the grain will quadruple the flow of water. Thus the flow through a sand whose effect size of grain is 1 mm. is 10,000 times the flow through a soil whose effective siz grain is 0.01 mm. The variation of flow with temperature is also important, as flow at 70° F. is about double that at 32° F. The variation in porosity is quite important as the variation in temperature.

From the table on page 155 it appears that if two samples of the same sand packed, one sample so that its porosity is 26 per cent and the other sample so tha porosity is 47 per cent, the flow through the latter sample will be more than se times the flow through the former sample. If the two samples of the same sand packed so that their porosities are 30 per cent and 40 per cent, the flow through latter sample will be about 2.6 times the flow through the former sample. Th facts should make clear the enormous influence of porosity on flow, and the ina quacy of a formula of flow which does not take it into account.

Part of the expression on the right side of formula (3) or (4) depends only u the character of the soil through which the water is passing. Representing this k, we have

$$k=0.2012\,\frac{d^2}{\mu K}=Md^2$$

and the formula for the flow becomes

$$q=k\,\frac{ps}{h},$$

which is essentially Darcy's formula. The constant k is the quantity of water tha transmitted in unit time through a cylinder of the soil of unit length and unit cr section under unit difference in head at the ends. We shall frequently refer to k the transmission constant, or merely as the constant of a soil.

Rates of flow.—It should be especially noted that the velocity of flow through soil for the pressure gradients and size of grain that commonly occur is exceeding slow, and much less than might at first be supposed. Darton states that the rate of fl in the sands of the Dakota formation, from which the remarkable artesian wells South Dakota draw their supply, does not exceed a mile or two a year. Mr. E. Rogers reported to the Denver Society of Civil Engineers that American estima agree with careful and exhaustive studies of French engineers, which show the av age velocity in sands to be about a mile a year, or about an eighth of an inch a mi ute. In Arizona the rate has been figured out as between one-fourth and one-thi of an inch per minute, while on Arkansas River above Dodge, Kans., a ditch a m long and 5 feet below the water table in the sand developed a flow of about thr eighths inch per minute.

Velocity of water in sands of various effective sizes of soil grain and the maximum flow or transmission constant for each soil.

[Porosity, 32 per cent; temperature, 50° F. Results for other porosities can be found by the use of table on page 158, and for other temperatures by the use of table on page 154.]

1. Diameter of soil grain.	2. Velocity, pressure gradient 1:1.	3. Velocity, pressure gradient 1:1.	4. Velocity, pressure gradient 100 feet to 1 mile.	5. Maximum flow, or transmission constant, *k*.	6. Logarithm of numbers in column 5.	7. Kind of soil.
Mm.	*Inches per minute.*	*Miles per year.*	*Miles per year.*	*Cubic feet per minute.*		
0.01	0.0014	0.0113	0.00026	0.000036	5.5569	Silt.
.02	.0054	.0452	.00102	.000144	6.1590	
.03	.0122	.1016	.00230	.000324	6.5111	
.04	.0218	.1807	.00408	.000577	6.7610	
.05	.0340	.2823	.00638	.000901	6.9548	Very fine sand.
.06	.0490	.4065	.00918	.001298	7.1132	
.07	.0667	.5534	.01250	.001766	7.2471	
.08	.0871	.7228	.01633	.002308	7.3621	
.09	.1103	.9147	.02066	.002920	7.4654	
.10	.1361	1.129	.02551	.003605	7.5569	Fine sand.
.12	.1961	1.627	.03674	.005192	7.7153	
.14	.2668	2.213	.05011	.007065	7.8491	
.15	.3063	2.541	.05753	.008112	7.9091	
.16	.3485	2.892	.06382	.009228	7.9651	
.18	.4412	3.659	.08266	.01168	8.0675	
.20	.5446	4.518	.1021	.01442	8.1590	
.25	.8509	7.058	.1594	.02253	8.3528	Medium sand.
.30	1.225	10.16	.2296	.03244	8.5111	
.35	1.668	13.84	.3125	.04417	8.6451	
.40	2.178	18.07	.4081	.05768	8.7610	
.45	2.757	22.87	.5165	.07300	8.8633	
.50	3.403	28.23	.6377	.09012	8.9548	Coarse sand.
.55	4.119	34.17	.7718	.1090	9.0377	
.60	4.901	40.65	.9183	.1298	9.1132	
.65	5.751	47.81	1.077	.1523	9.1827	
.70	6.671	55.34	1.250	.1766	9.2471	
.75	7.660	63.53	1.435	.2028	9.3071	
.80	8.714	72.28	1.633	.2308	9.3631	
.85	9.835	81.57	1.843	.2604	9.4157	
.90	11.03	91.47	2.066	.2920	9.4654	
.95	12.28	101.9	2.302	.3253	9.5123	
1.00	13.61	112.9	2.551	.3605	9.5569	Fine gravel.
2.00	54.46	451.8	10.21	1.442	.1590	
3.00	122.5	1,016	22.96	3.244	.5111	
4.00	217.8	1,807	40.81	5.768	.7610	
5.00	340.3	2,823	63.77	9.012	.9548	

The table on page [157] gives the velocity of movement of water in sands of various grades for different pressure gradients. Column 1 gives the effective size of the soil grains in millimeters. As already stated, this size is such that if all grains were of that diameter the soil would have the same transmission capacity that it actually has; column 2 gives the velocity of flow, or the rate at which the water moves through the ground in inches per minute under a pressure gradient of 1 foot difference in head to each foot of distance; column 3 gives the velocity of flow reduced to miles per year, the pressure gradient being the same as in column 2; column 4 gives the velocity of flow in miles per year under a pressure gradient of 100 feet to the mile. The velocity for a pressure gradient of 10 feet to the mile would be one-tenth of the numbers in this (fourth) column, and so on for other gradients; column 5 gives the actual discharge in cubic feet per minute for each square foot of cross section if the pressure gradient be 1 foot difference in head in each foot of distance. For the pressure gradient of 1 foot difference in head for each 100 feet in distance the flow per square foot will be 0.01 of the tabulated numbers, and so on for other gradients. The numbers in this (fifth) column have also been called the "transmission constant," and have been represented in the formulas by k.

Relative flow of water through sands of same effective size grain, but packed so as to possess different porosities.

Porosity, or per cent of voids.	Relative flow.
30	0.81
32	1.00
34	1.22
36	1.47
38	1.76
40	2.09

Maximum flow.—Inasmuch as the flow of ground water is nearly always caused by a difference in head due to gravity only, the maximum flow that is possible is found

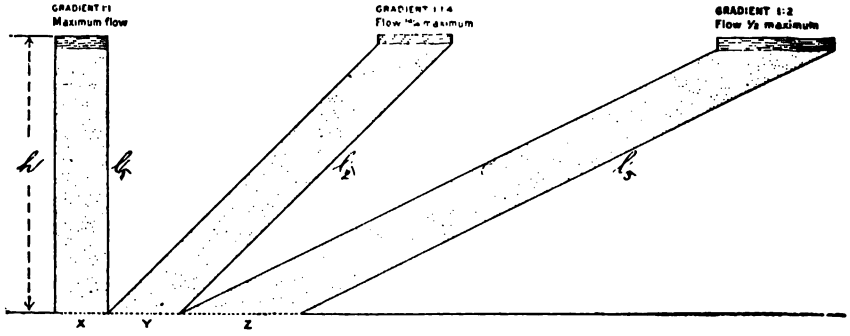


FIG. 22 (7 of Slichter).—Diagram illustrating various pressure gradients and the maximum flow. In these three cases the upper portions of the soil columns are supposed to be supplied with water as fast as it can flow through the columns. The escape at X, Y, Z is supposed to be perfectly free. The head under which the flow takes place is h in each case, as shown at the left of the figure. The various lengths of the soil columns, l_1, l_2, and l_3 produce the pressure gradients $h/l_1=1$; $h/l_2=\frac{1}{1.4}$; and $h/l_3=\frac{1}{2}$, respectively, with the resulting flows in proportion if the material in the various columns be the same.

in the case in which the ground water is free to move in a vertical direction, as in a perfectly underdrained sand-filter bed. The motion in this case is due to the weight of the water of saturation, and the flow is, of course, greater than would be the case if the water were obliged to flow in a direction inclined to the vertical instead of in the vertical direction, as supposed. These facts are illustrated in fig. 22. The flow in the case of pressure gradient 1:1 forms a most convenient basis for calculation, and it is frequently called, as suggested by Hazen, the maximum flow. The flow for any other gradient is immediately calculable from the maximum flow—for a gradient 1:100 the flow being, of course, one one-hundredth of the maximum flow.

The appropriateness of the term maximum flow is illustrated by fig. 23, which shows the original water table and the depressed water table due to the construction of a drainage ditch. It is plain that the pressure gradient for all of the streams of flow marked by arrowheads is less than the gradient 1:1. If the wetted area of the ditch be multiplied by the maximum flow for the kind of material in which the ditch has been excavated, the flow thus computed will in every case exceed the flow actually determined by measurements of the yield of the ditch.

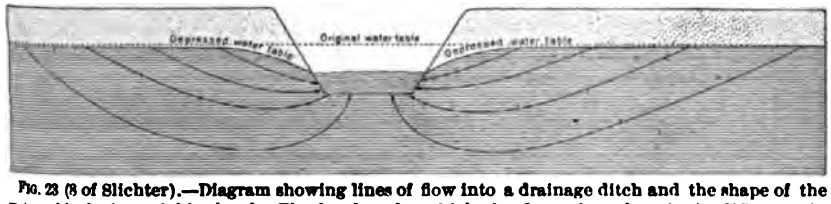


FIG. 23 (8 of Slichter).—Diagram showing lines of flow into a drainage ditch and the shape of the water table in its neighborhood. The head under which the flow takes place is the difference in height of the original water table and the level of the surface of the water in the ditch. This is much less than the lengths of the curved lines of the flow into the ditch, hence the rate of flow must be much less than the so-called maximum flow.

Velocity of flow.—There is not uniformity in the use of the term velocity as applied to the motion of ground waters. We use the term to express the rate (measured as so many feet a day, etc.) at which the water advances through the porous medium, irrespective of the amount of water thus advancing. The amount of ground water (measured in cubic feet per minute, etc.) passing through a given cross section the writer has called the flow or the discharge. It is equal to the velocity multiplied by the porosity. Some measure velocity as a rate of motion in a solid column of same area as the cross section of the porous medium. This is the same magnitude which we have called flow.

In using the table on page 157 one should use the numbers in columns 2, 3, or 4 if the velocity of ground water is wanted, but should pass to column 5 if the flow or yield is required. Thus, suppose it is desired to find the rate of motion of ground water through a bed of sand which slopes 10 feet to the mile: The results can be found for various materials and grades of material by dividing the numbers in column 4 by 10, since a slope of 10 feet to a mile will cause but one-tenth of the velocity existing for a slope of 100 feet to a mile. For materials of various grades we obtain the following results:

Velocity of ground water in materials of different grades, pressure gradient 10 feet per mile.

Material.	Miles per year.	Feet per year.
Fine sand, 0.2 mm. diameter	0.010	52.8
Medium sand, 0.4 mm. diameter	.041	216.0
Coarse sand, 0.8 mm. diameter	.16	845.0
Fine gravel, 2 mm. diameter	1.02	5,368.0

Example.—Suppose that it is desired to ascertain the amount of water that w pass through a bed 200 feet deep and 1,000 feet wide, having the same slope as th just mentioned. This problem requires us to find the flow, and the numbers us in the computation should therefore be taken from column 5 of table on page 1 The flow for one square foot of cross section of the bed will be $\frac{1}{5}\frac{1}{0}\frac{0}{0}$ of the ma mum flow given in that column for material of various grades, and the total flow found by multiplying the maximum flow by $\frac{1}{5}\frac{1}{0}\frac{0}{0} \times 200 \times 1{,}000$, which gives t following results for the same materials described in the preceding table:

Flow of ground water in materials of different grades through a bed of vertical cross sect 200 by 1,000 feet, sloping 10 feet per mile.

	Cubic feet per minu
Fine sand	8
Medium sand	2
Coarse sand	87
Fine gravel	546

The estimates in the table on page 157 were based upon a porosity of 32 per cen For other porosities the results must be changed by the percentages shown in t table on page 158. Thus all of the results just found must be increased by about per cent if the porosity of the material be 35 instead of 32 per cent.

FACTORS IN SLICHTER'S METHOD.

In order to apply the principles above quoted it is necessary, in ad tion to the facts already stated, to know (1) the area of cross sect through which the underflow passes; (2) the porosity of the materi and (3) the temperature at the depth at which the flow occurs.

Area of cross section.—On the assumption that the principal sou of the underflow is Salt River, and that the underflow passes in p down the present valley past Tempe and in part to the south, east the Salt River Mountains, it is evident that the open plain betwe Tempe and the Salt River Mountains and between the Salt River a Sacaton mountains gives a measure of the width of the underflo Since the principal part of this underflow passes through the bowl beds and comparatively little through the finer material, the practi width of the underflow is much less than the spaces indicated betwe the mountains. For all practical purposes the width of the underfl probably does not differ materially from that given in the sectio on Pl. XXI, or about 15 miles.

The thickness of the bowlder beds can not be stated with any deg of accuracy, since many of the wells do not reach the bottom of t bowlders. The thickness varies greatly from place to place, but general is greater near the center of the bed than at the sides, as in cated in the sections just referred to. The wells in the regions n these sections penetrate on the average about 150 feet of gravel a bowlders. Neglecting, then, the finer materials through which a min quantity of water finds its way, and neglecting the unknown thickn of bowlders which the wells do not penetrate there remains an avera

depth of 150 feet across a width of 15 miles, or 11,880,000 square feet, as the working area of cross section of the underflow. The actual area of cross section is greater than this, owing to the unknown thickness of the bowlder beds left out of account, but how much greater is not known. In order to keep well on the side of conservatism the figure is made no larger than known facts warrant.

Temperature.—Since the volume of water passing as underflow varies with the temperature, the temperature of several wells was determined, as follows:

Temperature of wells in Salt River Valley, Arizona, in 1904.

Well.	Location.			Depth.	Temperature.	Time.
	Township.	Range.	Section.			
				Feet.	° *F.*	
Consolidated Canal Co. No. 1	1 S.	5 E.	22	375	84.6	January 19.
Do	1 S.	5 E.	22	150	81.1	Do.
Murphy-McQueen	1 N.	5 E.	34	340	78.1	January 20.
Do	1 N.	5 E.	34	150	77.6	Do.
E. F. Kellner	1 N.	1 E.	6	324	82.3	January 15.
Valley Seedless Grape Co	1 S.	4 E.	4	319	74.4	December.

With the exception of the Kellner well, the wells in which the temperature was determined are those in active operation. The lowest horizons at which readings were obtained are below the bottom of the bowlder bed. In two wells readings were taken at a depth of 150 feet. The temperature at this depth is the temperature of the water of the underflow, since at that depth the thermometer was in the midst of the bowlder bed.

An inspection of the table indicates a considerable diversity of temperature. In the case of wells in which readings were taken at more than one depth the downward increase in temperature differs materially. In the Consolidated Canal Company well an increase downward is shown of 3.5° F. in 250 feet, while in the Murphy-McQueen well an increase of only 0.5° F. occurred in 190 feet. It is probable that the circulation of the underground water causes the differences in the temperature. Since the waters of the underflow follow the paths of least resistance, a certain quantity of water may be near the surface at one point and in the course of its journey be far beneath the surface at another point. This circulation of the water tends to destroy the regularity in the increase of temperature downward which might otherwise obtain. Variations such as those indicated above are to be expected.

Mechanical analyses of the water-bearing material of Salt River Valley—Continued.

GEORGE U. COLLINS.

Sieve marked.	Size of separation of the sieve, in millimeters.	Quantity held by each sieve, in grams.	Quantity passing each sieve, in grams.	Per cent of total weight of grains less than 1 inch in diameter.	Per cent of total weight of entire sample.
.....	[a] 0.152	20.5	.....	.....	.....
120	.152	.8	20.5	4.1	2.05
100	.182	14.5	21.3	4.2	2.1
80	.235	14.5	35.8	7.2	3.6
60	.320	23.1	50.3	10.6	5.3
50	.390	47.1	73.4	14.7	7.35
40	.460	167.1	120.5	24.1	12.05
20	.930	35.7	287.6	57.5	28.75
10	2.040	17.7	323.3	64.6	32.3
6	3.900	159.5	341.0	68.2	34.1
.....	[b] 3.900	500.5	659.5	.....	65.9
.....	.....	.....	.....	[c] .31	[c] .43

ONE-HALF MILE NORTH OF COLLINS'S.

.....	[a] 0.152	10.5	.....	.....	.....
120	.152	1.0	10.5	2.1	1.05
100	.182	11.3	11.5	2.3	1.15
80	.235	10.7	22.6	4.5	2.25
60	.320	18.6	33.3	6.7	3.35
50	.390	25.7	51.9	13.8	6.9
40	.460	117.5	77.6	15.5	7.75
20	.930	126.5	195.1	39.0	19.50
10	2.040	53.2	321.6	64.5	32.25
6	3.900	124.5	374.8	74.9	37.45
.....	[b] 3.900	499.5	624.5	.....	62.6
.....	.....	.....	.....	[c] .35	[c] .55

[a] Less than. [b] Larger than. [c] Effective size.

An effort was made to select the samples in such a manner that they would be representative of the material from which the best pumping plants draw their supply. It will be noted that the samples are all from the regions previously indicated as containing the bowlder beds. While only one sample is from the Mesa region, it is probable that the material represents the gravels there as faithfully as it does those of the Phoenix region. The samples are taken directly from the native material, as exposed in the sides of the well, and are thought to represent adequately the best water-bearing material of the valley.

In each case the proportion of material more than 1 inch in diameter is estimated as half the sample. Since bowlders occur 2 feet in maximum diameter it is obvious that no account of them can be taken in a small sample. It is certain that in some cases the proportion of large material is greater than half. Pebbles 1 inch or more in diameter were discarded and the remainder passed through standard sieves of sizes indicated in the following table. The work was done at the assay office of J. Q. A. King, of Phoenix, and the weight of the various sizes of material was accurately determined as indicated below:

Mechanical analyses of the water-bearing material of Salt River Valley.

RIVER GRAVELS.

Sieve marked.	Size of separation of the sieve in millimeters.	Quantity held by each sieve in grams.	Quantity passing each sieve in grams.	Per cent of total weight of grains less than 1 inch in diameter.	Per cent of total weight of entire sample.
.....	[a] 0.158	31.1	.....	.....	.....
120	.152	3.1	31.1	6.3	3.15
100	.182	29.6	34.2	8.9	4.45
80	.235	25.8	63.8	12.8	6.4
60	.320	50.0	89.6	17.9	8.95
50	.390	97.2	139.6	27.9	13.95
40	.460	225.0	236.8	47.3	23.65
20	.930	23.6	461.8	92.6	46.3
10	2.040	3.1	485.4	97.7	48.85
6	3.900	10.4	488.5	97.9	48.95
.....	[b] 3.900	498.9	510.4	.....	52.1
.....	.....	.....	.....	[c] .21	[c] .43

[a] Less than. [b] Larger than. [c] Effective size.

Mechanical analyses of the water-bearing material of Salt River Valley—Continued.

GEORGE U. COLLINS.

Sieve marked.	Size of separation of the sieve, in millimeters.	Quantity held by each sieve, in grams.	Quantity passing each sieve, in grams.	Per cent of total weight of grains less than 1 inch in diameter.	Per cent of total weight of entire sample.
.....	[a] 0.152	20.5	.....	.....	.....
120	.152	.8	20.5	4.1	2.05
100	.182	14.5	21.3	4.2	2.1
80	.235	14.5	35.8	7.2	3.6
60	.320	23.1	50.3	10.6	5.3
50	.390	47.1	73.4	14.7	7.35
40	.460	167.1	120.5	24.1	12.05
20	.930	35.7	287.6	57.5	28.75
10	2.040	17.7	323.3	64.6	32.3
6	3.900	159.5	341.0	68.2	34.1
.....	[b] 3.900	500.5	659.5	.....	65.9
.....	.....	.....	.....	[c] .31	[c] .43

ONE-HALF MILE NORTH OF COLLINS'S.

.....	[a] 0.152	10.5	.....	.....	.....
120	.152	1.0	10.5	2.1	1.05
100	.182	11.3	11.5	2.3	1.15
80	.235	10.7	22.6	4.5	2.25
60	.320	18.6	33.3	6.7	3.35
50	.390	25.7	51.9	13.8	6.9
40	.460	117.5	77.6	15.5	7.75
20	.930	126.5	195.1	39.0	19.50
10	2.040	53.2	321.6	64.5	32.25
6	3.900	124.5	374.8	74.9	37.45
.....	[b] 3.900	499.5	624.5	.....	62.6
.....	.....	.....	.....	[c] .35	[c] .55

[a] Less than. [b] Larger than. [c] Effective size.

Mechanical analyses of the water-bearing material of Salt River Valley—Continued.

N. P. McCALLUM.

Sieve marked.	Size of separation of the sieve, in millimeters.	Quantity held by each sieve, in grams.	Quantity passing each sieve, in grams.	Per cent of total weight of grains less than 1 inch in diameter.	Per cent of total weight of entire sample.
.....	[a] 0.152	21.9	.....	.....	.....
120	.152	1.7	21.9	4.4	2.2
100	.182	12.2	23.6	4.7	2.35
80	.235	14.3	41.8	8.4	4.2
60	.320	24.8	56.1	11.2	5.6
50	.390	49.9	80.9	16.2	8.1
40	.460	220.5	130.8	26.2	13.1
20	.930	66.6	351.3	70.4	35.2
10	2.040	17.6	417.9	81.9	40.95
6	3.900	63.5	435.5	87.2	43.60
.....	[b] 3.900	499.0	563.5	.....	.....
.....	.....	.....	.....	[c] .29	[c] .42

D. B. HEARD.

.....	[c] 0.152	12.4	.....	.....	.....
120	.152	.9	12.4	2.5	1.25
100	.182	9.4	13.3	2.7	1.35
80	.235	7.7	22.7	4.5	2.25
60	.320	13.7	30.4	6.1	3.05
50	.390	21.7	44.1	8.9	4.45
40	.460	106.0	65.8	13.2	6.6
20	.930	80.0	171.8	34.4	17.2
10	2.040	45.5	251.8	50.5	25.1
6	3.900	201.5	297.3	59.6	29.8
.....	[b] 3.900	498.8	701.5	.....	.....
.....	.....	.....	.....	[c] .43	[c] .56

[a] Less than. [b] Larger than. [c] Effective size.

Mechanical analyses of the water-bearing material of Salt River Valley—Continued.

MURPHY-McQUEEN.

Sieve marked.	Size of separation of the sieve, in millimeters.	Quantity held by each sieve, in grams.	Quantity passing each sieve, in grams.	Per cent of total weight of grains less than 1 inch in diameter.	Per cent of total weight of entire sample.
.....	[a] 0.152	32.7	.....	.....	.....
120	.152	1.6	32.7	6.5	3.25
100	.182	20.5	34.3	6.9	3.45
80	.235	12.2	54.8	10.9	5.45
60	.320	26.0	67.0	13.5	6.75
50	.390	42.7	93.0	18.7	9.35
40	.460	138.5	135.7	27.7	13.85
20	.950	61.5	274.2	55.1	27.55
10	2.040	32.25	335.7	67.2	33.6
6	3.900	130.0	367.95	73.9	36.8
.....	[b] 3.900	497.95	532.25	.....	53.3
.....	.....	.....	.....	[c] .26	[c] .42

[a] Less than. [b] Larger than. [c] Effective size.

Following the example given by Slichter, the results of the mechanical analyses were tabulated, and the effective sizes determined for each sample, as shown in the following table:

Effective size[a] and uniformity coefficients of material from Salt River Valley as determined by Hazen's method.

	Diameters of effective size of total sample, in millimeters.	Diameters of effectivesize of material less than 1 inch in diameter, in millimeters.	Uniformity coefficient for material less than 1 inch in diameter.
River gravel	0.43	0.21	2.47
Geo. U. Collins	.43	.31	2.84
One-half mile north of Collins's	.55	.35	4.86
N. P. McCallum	.42	.29	2.31
D. B. Heard	.56	.43	9.3
Murphy-McQueen	.42	.26	4.61
Average	.47	.31	.....

[a] By *effective size* is meant a diameter of grain such that 10 per cent of the sample is less than that size. It is determined by the intersection of the curve and the 10 per cent line. The effective size differs materially according to the choice of material, as indicated in the foregoing tabulation.

An application of Slichter's formula to the underflow of Salt River Valley, using the effective size thus obtained, gives results which are obviously erroneous, since the quantity of underflow thus indicated is notably less than the quantity known to return to the surface and measured as water actually diverted for irrigation purposes.

A sample of the gravels was sent to Professor Slichter and tested in his apparatus. The sample was taken from George U. Collins's well, and probably represents the water-bearing gravels of the valley as well as any single sample can represent them. The quantity of material rejected as too large to handle was about one-half. The finer material was analyzed by Professor Slichter for porosity and effective size. I quote from his letters as follows:

MADISON, WIS., *March 20, 1904.*

* * * * * * *

I have gone over the samples of gravel you sent with the following results:

Porosity: The porosity of the sample of gravels, after carefully tamping them in the aspirator tube, was found to be 40.3 per cent.

Effective size: The fine portion of the sample that will go through a No 8 sieve was used for the determination. Triplicate determinations give for effective size of this portion of the sample 0.716 mm. The effective size of the actual material you sent is slightly greater, but our aspirator tubes are such that I can not safely introduce large pebbles into the instrument. I shall make an actual test with water of the entire sample as soon as I can do so.

Hazen's 10 per cent is worthless for nearly all western gravels. I have never yet found a sample of heterogeneous gravel that will test to correspond with his 10 per cent. The 50 per cent line is frequently about correct, although even this is often far from the true value.

CHAS. S. SLICHTER.

MADISON, WIS., *April 4, 1904.*

About two weeks ago I sent you results of tests of gravels from Collins's well by aspirator method. I inclose herewith further data.

After picking out the larger pebbles I separated the larger particles by standard sieves, and after each sifting determined porosity and effective size of the gravel passing the sieve. The gravels were packed in the cylinder by tamping while poured in place very slowly, and an effort was made to pack as closely as possible. You will note that the porosity changes greatly, and that the removal of the larger grains has a tendency to lower the effective size of the sample, with one or two notable exceptions.

I believe that the larger grains necessarily omitted from the sample probably would increase the effective size if we could use them. You will note that Hazen's 10 per cent is perfectly useless for all of the samples in the table. The 50 per cent line gives a value of grain nearer the true mean.

Gravel from George U. Collins's well, Salt River Valley, Arizona.

No. of sieve.	Per cent of sample held.	Per cent of sample passed.	Porosity of "pass."	Effective size of "pass," in millimeters.	Transmission constant of "pass" at temperature 80° F., in cubic feet per minute.
2	6.6	93.4	38.1	0.727	0.511
8	.....	.....	40.0	.716	.602
10	16.3	83.7	38.6	.63	.400
12	17.4	82.6	40.3	.68	.543
14	19.7	80.3	39.5	.63	.428
16	22.0	78.0	39.7	.63	.440
18	23.6	76.4	39.6	.62	.427
20	25.8	74.2	40.6	.71	.597
30	44.1	55.9	41.0	.56	.382
40	67.8	32.4	40.6	.42	.209

CHAS. S. SLICHTER.

APPLICATION OF SLICHTER'S METHOD.

It will be noted from the contours of the water table that the inclination of the table varies from 5 to 20 feet per mile, the inclination on the average being practically the same as that of the land surface. The gradient is practically 10 feet to the mile where the principal underflow occurs. This figure is therefore used in the following computation.

The porosity, as previously stated, may reasonably be assumed as 40 per cent, the effective size as 0.72 mm., and the temperature as 80° F. In order that the quantity of underflow may be expressed in acre-feet per year, the number of minutes in one year is placed above the line and the number of cubic feet in 1 acre-foot of water beneath the line.

Applying local values, therefore, Slichter's formula becomes:

$$q = \frac{11.3 \times 10 \times .72^2 \times 11880000 \times 525600}{5280 \times 43560 \times 20.318}\,[1 + .0187(80-32)]$$

acre-feet per year.

Solving this equation we have 148,196 acre-feet per year as the quantitative measure of the underflow of Salt River Valley, or a rate of flow of about 1,360 feet per year. In other words, assuming that the values chosen are correct, a quantity of water sufficient to cover 148,196 acres of land 1 foot deep each year enters the gravels of the valley and works its way at the rate of 1,360 feet per year through the valley fill. This is not a measure of the quantity of water in the gravels at any one time, but a measure of the quantity which passes any given cross section of the valley in one year.

COMPARATIVE DATA FROM OTHER REGIONS.

Owing to the great importance of arriving at an estimate as nearly correct as possible of the quantity of underflow it may be profitable to consider it from different standpoints. There are so many unknown factors and so many varying conditions that no quantitative estimate can be final. Such estimates are, however, of illustrative value in giving a measure of possibilities.

Observations have been made on the rate of movement of underground waters at many localities. L. C. Carpenter has published a paper[a] giving the results of his study on the rapidity of underflow, from which the following quotation is taken:

> Near Montrose, Colo., the velocity was found to be about 1 mile per year. At Fort Morgan, Colo., 15 feet per day, or a little more than 1 mile per year in soil and sand. On the Hoover ditch the velocity is 3.6 feet per day, or 314 feet per year in sand.

In the paper previously quoted, Professor Slichter gives rates of movement of underground water as follows:

> Weldon Valley canal, 1½ miles in five years, or 1,584 feet per year. Larimer County canal, 40 rods in five years, or 132 feet per year. Near Greeley, Colo., 2½ miles in ten years, or 1,320 feet per year. King River, California, 4.8, 4.3, and 16 feet per day, or 1,792, 1,580, and 584 feet per year. Centerville canal, California, 16 feet per day, or 5,840 feet per year. Kingsbury canal, California, 52 feet per day, or 3.6 miles per year. Arkansas River, Kansas, 2½ feet per day, or 913 feet per year. Near Garden, Kans., 12 feet per day, or 4,380 feet per year. Hondo and San Gabriel rivers, California, 3½, 4, 5½, and 7 feet per day, or 1,278, 1,460, 2,008, and 2,555 feet per year.

To the above data may be added the observations mentioned in Chapter I, that the underflow is made evident through the Bowen well by the collection at one side of floating bodies, and that in the Collins well floating blocks of wood indicate a current sufficiently swift to be plainly visible to the observer. This was noted on three different occasions each time after the well had been undisturbed for several days. On each occasion the velocity was practically the same and appeared to be affected by nothing except the normal movement of the underflow.

From the above data it appears that the rate of underflow as measured in several localities varies from a minimum of 132 feet per year to a maximum of 3.6 miles per year. Because of the application to follow, however, it should be noted here that the material through which the water passed at the above rate is, for the most part, soil or comparatively fine sand. In no case described is the material so coarse as that occurring in Salt River Valley.

[a] Carpenter, L. C., Seepage, or return waters, from irrigation: Colo. Agric. Exp. Sta. Bull. No. 33, 1896.

COMPUTATIONS OF VOLUME.

Since the maximum velocity previously quoted is 3.6 miles, or 18,90[illegible] feet per year, it seems probable in view of the great freedom of move ment of the underground waters in a number of places in Salt Rive Valley, as shown by pumping tests and otherwise, that the effective siz may be much greater in places than 0.72 mm., and the porosity ma be greater than 40 per cent with a rate of movement correspondingl greater. It is reasonable to suppose that in material of such varyi size as that of Salt River Valley accumulations of the coarse gra and bowlders in places occur with little sand and silt. Such beds wo offer little resistance to the underflow and a velocity even exceedi the maximum quoted above (3.6 miles) might easily occur. It is e dent from the quantity of return water—more than 100,000 acre-fe per year—that the underflow of which this return water is a part m easily amount to the 148,196 acre-feet per year indicated by the app cation of Slichter's formula, and may possibly be much greater. L it be remembered, however, that the 100,000 acre-feet of return wat is from Gila and Salt rivers combined, there being no way at presen of separating the two.

It may be useful to compute the volume of underflow for severa possible velocities, bearing in mind always that since the actual rat of underflow is unknown, the results are only possibilities and have only illustrative values.

In a former paper[a] on the underground waters of Gila Valley cer- tain estimates of the possible quantity of the Gila underflow were made. Much less is known of that valley than is known of Salt River Valley, and the estimates are less likely to be correct than those for Salt River Valley. Since the two underflows join and their relative values are not determinable, the estimates made in that paper are quoted for comparison with those herein given. The two underflows should be considered together for the reason that the only reliable measure of the quantity of underflow at hand is the return water of Salt and Gila rivers combined.

Quantitative estimates of underflow of Salt and Gila rivers.

	Area of cross section in square feet.	Acre-feet per year at velocity of—			
		1,360 feet per year.	¼ mile per year.	1 mile per year.	2 miles per year.
Salt River	11,880,000	148,196	287,760	575,520	1,151,040
Gila River	2,872,320	35,830	69,564	139,128	378,256
Total		184,026	357,324	714,648	1,529,296

[a] Lee, W. T., The underground waters of Gila Valley, Arizona: Water-Sup. and Irr. Paper No. 104, U. S. Geol. Survey, 1904.

It will be observed that with the given cross sections and a porosity of 40 per cent a velocity of one-half mile per year yields a volume of 357,324 acre-feet per year. Considering the great volume of return waters—100,000 acre-feet or more east of the Buckeye canal and a large though unknown volume west of that canal—and considering also the coarseness of the water-bearing material and the freedom of movement evident at many of the pumping plants, it seems probable that the rate of movement may be greater than the computed rate of 1,360 feet per year, and that the average velocity may be more nearly one-half mile per year, making a normal volume of underflow of 287,760 acre-feet per year in Salt River Valley and 69,564 acre-feet per year in Gila Valley, or a total of 357,324 acre-feet of water entering the underflow each year.

THE RESERVE.

The computations thus far have dealt only with the flow—that is, with the volume passing through the assumed cross section during the year; they take no account of the water already in the valley-fill. An estimate of this amount may be instructive.

There are in Salt River Valley, north of the Pima Indian Reservation, about 525 square miles (fig. 21) beneath which underground water occurs less than 50 feet below the surface. About 275 square miles of this area are underlain by bowlder beds. These beds are known to be thicker than 150 feet, but how much thicker can not be stated. They are known to extend beyond the limits of the area indicated in the map, but to what extent remains unknown. Over a considerable part of the 525 square miles the water is only 10 to 20 feet beneath the surface. Assuming the limit of lift for pumping as 65 feet, and allowing 15 feet for the local depression of the water table due to the action of the pump, it is evident that pumps placed in the lower portions of the region might permanently lower the level of underground water 35 feet and still obtain water within the limit of cost. It is furthermore evident from the readiness of movement of the underground waters that pumps placed on the lower grounds might readily draw from the whole region and depress the water table uniformly.

It is thought that water contained in the vast quantities of material beyond the 50-foot contour will much more than compensate for the area in which the finer material predominates, as indicated in fig. 21, and that it is safe to assume a porosity of 40 per cent for the material over an area of 525 square miles as a working basis. In order that the water table shall be permanently lowered 35 feet the gravels must part with the water contained in the spaces, amounting to 40 per cent of the volume over an area of 525 square miles, or 336,000 acres, and 35 feet deep. This amounts to 4,704,000 acre-feet of water.

Viewing the problem from another standpoint, there is available for pumping in the gravels at the present time, provided none escapes, water in sufficient quantity to cover the 336,000 acres to a depth of [illegible] feet. This water if applied to 200,000 acres, the estimated area cultivated in Salt River Valley, would supply the entire area, allowing [illegible] acre-feet of water per acre per year, for nearly 40 years.

It should be stated in this connection that the immense quantity of water contained in the gravels is continually moving down the valley. While the water table remains constant, the inflow at the head and sides of the valley equals the outflow or discharge at the lower end. The total quantity, therefore, should be considered as a reserve rather than an available supply. The quantity entering the underflow represented by the volume of flow is the maximum amount which can be considered as permanently available for pumping. This amount might be withdrawn continuously if the pumps could be arranged in such a manner as to secure the whole flow. Since this is obviously impossible, something less than the normal flow is permanently available for pumping. A greater draft will draw upon the reserve and continued use of the reserve may lower the water table in time to a horizon too deep for pumping.

From the quantity of the reserve it is evident that pumps might be operated for years before the reserve was exhausted, provided the natural escape of the water from the valley could be prevented. But since this escape is great and constant—more than 100,000 acre-feet per year (besides an unknown quantity passing as underflow in the Buckeye region as previously described)—any great quantity of water extracted by pumps would probably cause a material depression of the water table.

The elevation of the surface where the underflow returns in part, west of Phoenix, is about 200 feet lower than at Mesa. Should the inflow cease the surface of underground water must eventually lower to the level of the point where the water escapes. It is the friction due to passage through the sands and gravels retarding the flow, coupled with the supply from the inflow, that maintains the water gradient. When this balance is disturbed, a disturbance of the water table must result. The practical question is: How much of a disturbance in the way of pumping can be made and still have water within pumping distance?

It is evident that, other things equal, an increase of water entering the valley will raise the water table and a decrease will lower it; an increased draft at the lower end of the valley, whether by escape as seepage or by the demand of pumps, will lower the water table; water withdrawn by pumps at any point in the valley will affect the water table, particularly below the pumps and in general over the whole valley, by disturbing the equilibrium established in nature.

A lowering of the water table of several feet has taken place during the past few years. How much of this lowering, if any, is due to the operation of pumps and how much to the scarcity of water during the past few years, owing to the scant rainfall, is not determinable at present.

The underflow, even though the volume be great, should not be considered as inexhaustible. There is a large quantity of water available; a quantity well worth the necessary expense of pumping plants for securing it. But it is fairly certain that a large number of pumps run continuously will cause a permanent lowering of the water table, and pumps established on high ground may find the lift too great for economic operation after a few years.

Probably the most satisfactory way of utilizing the underground water is to withdraw by pumps no more than the normal flow, leaving the gravels saturated as a reserve to be used in times of need and replaced in times of plenty; in other words, to use the water in the valley fill as a reserve supply rather than to exhaust it quickly in the extension of cultivated land, with the consequent loss of property when the water level falls beyond the reach of the pumps.

PRACTICAL POROSITY.

The proportion of voids given for various diameters of sand grains usually assumes a comparatively uniform size of grain. It is obviously erroneous in heterogenous materials to make computations for any selected size or even for an average size. The finer material packs into the interstices of the coarser. It would be entirely possible to have such materials packed in such a manner as to hold very little water. No doubt such cases occur in the valley fill. There is also no doubt that places may be found where coarse material occurs apart from the fine, and also where, although coarse and fine exist together, they are loosely packed and allow a free passage of water.

It is furthermore obvious that since the sands can not be pumped dry, much water might be held by them which is properly a part of the underflow, but which is not available for pumping. In order to arrive at an approximation of the quantity of water available for pumping in the mixed gravels of the valley, a series of measurements were made by filling a barrel with gravel and sand and measuring the quantity of water which could be poured into it, assuming that this quantity would be a fair measure of the quantity that might be withdrawn by pumping. In order to obtain representative material, the measurements were made at a well east of Phoenix (G. W. Smith's), where the material thrown from the well lies undisturbed. The barrel held 46⅝ gallons measured by a standard graduate. Such material was first selected as seemed to be a fair average of the water-bearing materials observed throughout the valley. It was sand, pebbles, and

bowlders up to 8 inches in diameter. The sand was slightly moist from a shower which fell the day before the measurements were made. The material was carefully packed in the barrel in order to approximate as nearly as possible the natural conditions. Water was then poured slowly into the material until the barrel was full. It was found that 10½ gallons of water could be poured into the barrel, representing 20.5 per cent of the total space. These gravels might easily be packed more closely in nature than they were in the experiment, and the amount of water that could be pumped from them, leaving them damp since all the water could not be withdrawn, would be something less than 20 per cent of the total bulk.

For a second experiment a place was selected where only coarse gravel and bowlders occurred, varying in size from half an inch to 8 inches in diameter. With this material in the barrel, 16⅜ gallons of water were added to fill the barrel, or 35.8 per cent of the total space. In this case, as in the former one, the percentage of voids in nature would be something less, owing to the closer packing of the gravels. The actual quantity of water available for pumping in this case is something less than 35 per cent of the volume.

Volume of water contained in sands and gravels of different porosity 35 feet deep.

[In acre-feet.]

Valley.	Area in acres.	Porosity.					
		15 per cent.	20 per cent.	25 per cent.	30 per cent.	35 per cent.	40 per cent
Salt River.....	336,000	1,764,000	2,352,000	2,940,000	3,528,000	4,116,000	4,704,000
Gila River	224,000	1,176,000	1,568,000	1,960,000	2,352,000	2,744,000	3,136,000
Total ...	560,000	2,940,000	3,920,000	4,900,000	5,880,000	6,860,000	7,840,000

It is evident that the estimated volume of the reserve previously stated as 4,704,000 acre-feet is much greater than the volume which could actually be withdrawn by pumping. In order to have something tangible to consider, the preceding table has been so prepared as to show the volumes of water contained in a given volume of sand and gravel with assumed porosities. The area is chosen to include only the land beneath which water is 50 feet or less below the surface, and where the water level might be lowered 35 feet and still be within pumping distance. Since there is a large area beyond the 50-foot contour beneath which water occurs which is left out of account, it is evident the volumes given in the table are smaller than the actual quantity within reach.

The quantitative estimates for Gila Valley are inserted because of the close association of the two valleys.

It is probable that the practical porosity—that is, the percentage of volume consisting of water actually available for pumping—is somewhere between 15 and 30 per cent.

A pumping plant of average capacity, such as those of the Consolidated Canal Company, throws a continuous stream of about 200 inches. If operated without stop, one pump would raise 3,620 acre-feet of water per year. But since there is always more or less stoppage for repairs, etc., it is assumed, for convenience, that one pump will raise about 3,000 acre-feet per year. The number of pumps required to raise the possible volume of underflow are as follows:

Number of pumps required to raise the water[a] of the underflow.

Number of pumps of 3,000 acre-feet per year capacity.	Volume of underflow in acre-feet.
30	148,196
96	287,760
192	575,520
384	1,151,040

[a] For volume, see tables on pp. 170, 174.

If a volume of underflow of 287,760 acre-feet per year be accepted, as previously suggested, it is evident that 96 pumps would lift the entire flow, provided it could all be secured. It is evident, however, that it could not all be secured. A withdrawal of the supply in any large measure must lower the water table, since the escape of the seepage waters below can not be prevented. The withdrawal of the total supply, if that were possible, would cause a lowering of the water table in time to the level of the outlet, a distance of about 200 feet for the Mesa region. Any depression of the water table due to the loss by seepage at the lower end of the valley will in turn depress the water table in the pumping region. It is therefore evident that, with an inflow of 287,760 acre-feet per year, 96 pumps would soon depress the water table beyond easy reach. In other words, in order to maintain conditions such that the underflow may be permanently and regularly useful, the pumps must be limited, under assumed conditions, to a number notably less than 96.

It is impossible at the present time to give more than a rough estimate of the quantity of water now being withdrawn from the underflow. Few of the pumps run continuously and there are many that run only occasionally to secure irrigation water when other sources fail. The most accurate estimate possible at present (summer of 1904) of the water pumped is 4,000 inches. This amount is pumped only during the summer. Should the pumps now in operation be run continuously

at the estimated rate (4,000 inches) they would supply about 54, acre-feet of water per year, or more than one-third of the minim estimated volume of the underflow.

If the reserve be considered as a part of the available supply i pumping, a much greater number of pumps might be operated f some time before the water table was lowered beyond reach. Tl pumping area described is about 36 miles in length. At the assume rate of underflow, water entering at the head of the valley above Mes would require seventy-two years to make the journey to the mouth o the Agua Fria. At this rate of movement water not only to the amount of the inflow but also large quantities of the reserve might be

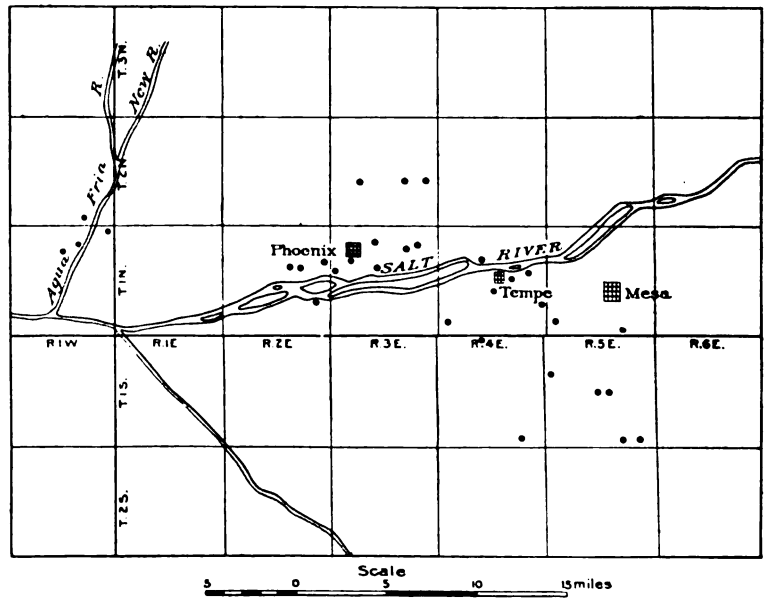


FIG. 24.—Map of Salt River Valley, showing location of pumping plants described.

withdrawn for years before the water table was permanently depressed beyond the limit of lift. Its recovery, however, would be equally slow. If the pumping project is pushed too far, it is inevitable that the more inefficient pumping plants, especially those on higher ground, must be abandoned, owing to increasing lift as the water table is depressed. In this, as in other cases of competition, only the fittest can survive.

If it be objected that the assumed velocity of half a mile per year is too small, and that 1 mile or more per year is the rate of movement, then the volume of flow is correspondingly greater and the number of possible pumping plants will be greatly increased.

COST OF PUMPING WATER.

SALT RIVER VALLEY.

Comparatively little has been known up to the present time of the actual expense of pumping water in Salt River Valley. The pumping tests described in the first chapter and summarized below, deal with conditions as they actually exist. In most cases these conditions are far from ideal. Indeed there are few pumping plants in the valley which are working with the efficiency that could reasonably be expected. There have been no experiments until recently tending to show the most economical method of pumping water, and there is no agreement among those using pumped water as to what kind of pump or what power is best, or even how to construct a well in order that it may give the best permanent results. It is thought that the computations of cost of raising water at the various pumping plants just as they exist with all their imperfections may be of value by way of comparison with guaranteed cost, which is usually based on ideal conditions.

I have excluded from the list all computations except those which I have reason to believe are essentially correct. In some cases certain elements are doubtful; for example, at the Collins well the exact amount of wood used was not obtained. It should be stated also that the test runs upon which the computations are based were short, varying from one to three hours. The figures consequently show the rate irrespective of stoppage for repair or for other cause.

In making the computations I have included in the cost of the acre-foot interest at 7 per cent per annum on the investment, the legal rate of interest in Arizona, and 10 per cent per annum depreciation, the time in each case being the time required for pumping 1 acre-foot of water. No allowance is made for stoppages. In each case the expense for oil and incidentals is estimated at 5 cents per acre-foot.

Records of pumping plants in Salt River Valley, Arizona, on which pumping tests were made.

Name.	Kind of well.	Size.	Total depth.	Depth to water.	Amount of lowering.	Total lift.
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Murphy-McQueen	Drilled	1	1,305	23	19	44
Consolidated Canal Co.:						
No. 2	do	1¼	246	36	15	50.65
No. 3	do	1¼	266	37	11	47.56
Valley Seedless Grape Co	do	1	348	30	11.5	47
Tempe waterworks	do	1	152	23	14	219
T. J. Parry	Dug	40 by 60	21	17	1	18
L. Kunz	do	6 by 6	24	18	(?)	18
Geo. U. Collins	do	60 by 100	29	14	6	22
Nelson & McIlwaine	do	7	26	16	5	21
John Heaton	Dug		12	(?)	(?)	28
	Drilled	1	45			

Records of pumping plants in Salt River Valley, Arizona, on which pumping tests were made—Continued.

Name.	Kind of pump.	Power.	Cost of well and pump.	Capacity per minute.	Cost per acre-foot.	Cost per acre-foot per foot of lift.
				Gallons.		
Murphy-McQueen[a]	Centrifugal.	Steam and wood.	.....	3,038	$2.27	$0.051
					2.97	.068
Consolidated Canal Co.:						
No. 2	....do....	Electric..	$8,000	2,223	2.84	.056
No. 3	....do....	....do....	8,000	2,273	2.69	.054
Valley Seedless Grape Co	....do....	Gasoline..	.....	518	3.80	.08
Tempe waterworks	Triplex....	Electric..	3,700	275	14.55	.058
T. J. Parry	Bucket....	Gasoline..	900	673	2.91	.161
L. Kunz	Plunge....	Horse.....	250	62	1.14	.063
Geo. U. Collins	Centrifugal.	Steam and wood.	1,500	2,200	1.93	.07
					2.75	.124
Nelson & McIlwaine	....do....	Gasoline..	2,200	900	2.88	.137
John Heaton	Plunge....	....do....	500	120	3.87	.138

[a] Cost does not include interest and depreciation. If this be added, the total cost becomes approximately $2.97 per acre-foot or 6.8 cents per foot per acre-foot.

It has been estimated that electric power can be furnished at a cost not exceeding $50 per horsepower per year. In three of the pumping plants previously described the horsepower consumed at the pumping station is accurately known. Since these three use electric power, direct comparison can be made as in the following table:

Cost of pumping with power furnished at $50 per horsepower per year compared with present cost.

Name.	Horsepower consumed.	Present cost per acre-foot.	Cost per acre-foot with power at $50 per horsepower per year.	Present cost per acre-foot per foot of lift.	Cost per acre-foot per foot of lift with power at $50 per horsepower per year.
Consolidated Canal Co.:					
No. 2	42.88	$2.84	$0.60	$0.056	$0.012
No. 3	42.88	2.69	.59	.054	.0118
Tempe waterworks	31.51	14.55	3.62	.058	.0144

The experiments upon which these costs are based were performed by Engineer P. E. Fuller, and are thought to be very accurate. For irrigation purposes the first two are most reliable, since they are pumping stations established exclusively for irrigation. No allowance has been made for loss of time for repairs. With such an allowance the price per foot per acre-foot with power at $50 per horsepower per year will be slightly more than 1.2 cents. Owing

to the careful and painstaking experiments of Mr. Fuller this rate can be stated with considerable confidence.

As previously stated, there are places, for example near Tempe, where the water table is less than 10 feet beneath the surface. Allowing a local depression of 15 feet due to the action of the pump, or a total lift of 25 feet, water can be raised for 30 cents per acre-foot, a price much lower than the present cost of canal water.

The actual cost of canal water in Salt River Valley at present is somewhat difficult to estimate, owing to the manner in which water is sold. The price nominally paid is much less than the actual cost, for the quantity nominally paid for is seldom received. It is probable that the actual cost of canal water at the present time is little, if any, below $1 per acre-foot. With a lift of 65 feet, which has been assumed as the present limit, an acre-foot of water would cost 78 cents. The Consolidated Canal Company finds it profitable to pump water at a cost of $2.84 per acre-foot while others are pumping at a cost as high as $3.87 per acre-foot. At the rate of 1.2 cents per foot, water could be raised with profit from a depth much greater than 65 feet, and the pumping area indicated in the map (fig. 21) could be greatly extended.

COST OF PUMPING IN OTHER REGIONS.

It will be instructive to compare the cost of pumping water in Salt River Valley with the cost as determined elsewhere. The following extract contains some data which may be useful:[a]

COST IN ARIZONA, WISCONSIN, AND CALIFORNIA.

The reports of former years and this report have given meager returns from a few pumping plants, showing the cost of raising water. Mr. Code reports the details of tests made by him, and gives as his general conclusion that with wood at $4 per cord water can be lifted 45 feet for $2.50 per acre-foot, and that with power delivered to the pump at $60 per horsepower per annum water can be lifted 45 feet at a cost of $1 per acre-foot. Both these estimates include the cost of attendance and a fair rate of interest on the investment.

Professor King gives the cost of raising water in Wisconsin. At Madison water was raised 25 feet at a cost of $2.64 per acre-foot, using coal which cost $5 per ton. At Stevens Point water was raised 33 feet at a cost of $3.32 per acre-foot, using a gasoline engine, with gasoline at 11.98 cents per gallon.

Professor Chandler gives the cost of an acre-foot of pumped water in the Tule River Valley at from $5 to $7.40, with a lift of 71 feet and power costing $50 per horsepower per annum.

The following table gives all the data regarding the capacities of various kinds and sizes of pumps which have been included in all the bulletins published by this office:

[a] Report of irrigation investigations for 1901, No. 1: U. S. Dept. Agric. Bull. 119, 1902, p. 34.

Capacity of pumps.

Pump.	Power.	Lift.	Capacity per 24 hours.
		Feet.	*Acre-feet.*
2.5-inch Lawrence centrifugal	5-horsepower gasoline		0.264
5-inch Krogh centrifugal	12-horsepower gasoline	30	1.32
Do	do		.99
5.5 by 8 inch triplex-acting pump.	do	125	.594
8-inch centrifugal			8.80
Do			6.60
Do		19	7.26
Do			7.04
Do		14	8.80
Do	18-horsepower engine (burning wood).		4.40
Do		18	7.70
8-inch Krogh		32	6.60
10-inch centrifugal	80-horsepower engine	39	17.60
12-inch centrifugal		23	15.40
16-inch centrifugal	80-horsepower Frick engine	14.5	35.20
18-inch centrifugal			44.00
20-inch centrifugal		15	44.00
Double-cylinder 6-inch pump	4-horsepower gasoline		.396
Triplex pump, 5.5 by 8 inch plungers.	5-horsepower gasoline		.594
Compound duplex pumping engine.	80-horsepower boiler		132.00
Worthington compound duplex steam pumping engine.	do		176.00

COST OF PUMPING IN NEW MEXICO.

An instructive series of experiments has recently been made at the New Mexico Agricultural Experiment Station calculated to show the comparative merits of several makes of pumps. The most economic speed was determined for each make of pump tested, and the cost determined per acre of irrigating 3 inches deep, using wood for fuel at $2.25 per cord. In order that the table may correspond with those previously given, the figures have been altered to read in cost per acre-foot. Otherwise the figures are those given in the various tables by Vernon and Lester,[a] except those in the last column; there the cost is reduced to unit of lift.

[a] Vernon, John J., and Lester, Francis E., Pumping for irrigation from wells: N. Mex. Agric. Exp. Sta. Bull. No. 45, 1903.

Cost of pumping at New Mexico Agricultural Experiment Station.[a]

Name of pump.	Pump running at most economic speed, in gallons per minute.	Cost per acre-foot.	Lift.		Cost per foot of lift per acre-foot.
			Ft.	*in.*	
Van Wie	600	$2.05	27	10¼	$0.073
R. D. Wood	600	2.59	28	½	.092
Kingsford	824	2.39	34	5½	.069
Bryon Jackson	944	2.46	36	8½	.067
Fairbanks-Morse	824	2.47	35	8¾	.069

[a] Fuel is dry tornillo wood at $2.25 per cord.

COST OF PUMPING IN CALIFORNIA.

The principal expense of pumping is the fuel, and the great cost of fuel is responsible for the high rate of cost of pumping in Salt River Valley. In order to compare this with the cost where fuel is inexpensive, I give the following table of costs from pumping plants in California. The data were furnished by Thomas H. Means, of the Bureau of Soils, having been collected by his assistant, W. H. Knox. It appears from these data that water is pumped with crude oil and distillate as fuel, at a minimum cost of less than 1 cent per foot per acre-foot, as compared with a minimum of 8 cents in Salt River Valley, using distillate, and 5.4 cents, using electric power. It appears, also, that with fuel at the price paid in California, water is pumped cheaper than the estimated cost with electric power at $50 per horsepower per year, the minimum being 1.18 cents for electric power and 0.8 cent for crude oil. It should be stated, however, that allowance is made in the California rates for little besides fuel. It is thought that due allowance for interest, depreciation, etc., would bring the rate up to at least the estimated rate for electric power.

Cost of pumping in California.

[Data collected by W. H. Knox, of the Bureau of Soils of the Department of Agriculture.]

Owner.	Location.	Kind of pump used.	Source of supply.	Total lift.
				Feet.
M. T. Ireland	Fowler, Cal	Burton, 4-inch	Pond	15
J. Vincent	do	Krogh, 5-inch	Well	22
J. S. Brander	do	Krogh, 8-inch	do	20
John Hartly	Fresno, Cal	Richardson, 5-inch	Well	45
J. H. Marsh	Lone Star, Cal	Krogh, 6-inch	do	25
Aug. Ganfraw	Sanger, Cal	do	Slough	36
L. C. Jolley	Del Rey, Cal	Sampson, 6-inch	Pond	15

Cost of pumping in California—Continued.

Owner.	Capacity in acre-feet per hour.	Fuel used.	Cost of fuel per hour.	Cost per acre-foot per foot of lift.	Remarks.
			Cents.	*Cents.*	
M. T. Ireland	0.115	Distillate	6 to 7.5	4.3	
J. Vincent	.10	do	17	7.7	Plant not yet regulated for best results.
J. S. Brander	a.75	Crude oil	12.5	.8	Has been operating two years.
John Hartly	.207	Distillate	10	1.1	Distillate costs 10 cents per gallon.
J. H. Marsh	.15	do	6 to 7.5	2	12-horsepower engine—cost of fuel thought to be underrated.
Aug. Ganfraw	.3	Crude oil	a10	.9	
L. C. Jolley	.4	Distillate	11	1.8	

a Estimated.

COST OF PUMPING IN EGYPT.

It may be of interest to know the cost of well-established pumping plants abroad. Thomas H. Means, of the Bureau of Soils, who is familiar with irrigation operations in Egypt, has kindly furnished the following information for this paper:

Cost of pumping drainage water at Mex, Egypt.

Season.	Acre-feet pumped.	Price of coal per ton.	Cost per acre-foot per foot of lift.
			Cents.
1895–96	141,750		2.42
1896–97	175,800		2.31
1897–98	187,900		2.36
1898–99	230,800	$6.19	1.87
1899–1900	164,430	8.39	2.87
1900–1901	255,960	8.73	2.79

Equipment consists of five Farcot direct-acting centrifugal pumps and two 48-inch centrifugals, with a total maximum capacity of 1,400 cubic feet per second, though the normal output is not intended to exceed 1,125 cubic feet per second; lift about 10 feet. This is one of the largest pumping plants in the world.

Estimated cost of pumping drainage water at Kassasin, Egypt.—Equipment consists of two 30-inch centrifugals and one 20-inch, run by direct-connected double-expansion engines. Total capacity given as 88 cubic feet per second; expenses of plant about $20,000 per year, making cost of lifting about 4.8 cents per acre-foot per foot of lift.

VALUE OF WATER.

Having ascertained the cost of procuring water by pumping, it is well to know what return can reasonably be expected from its use. Prof. Alfred J. McClatchie, of the Arizona Agricultural Experiment Station, has published a paper dealing with this problem.[a] The following table (Table VI of McClatchie's paper) gives the returns realized from the use of water:

Record of principal crops grown on the farm of the Arizona Experiment Station during 1901.

	Amount of water applied previous to planting.	Date of planting.	Date of first irrigation.	Date of last irrigation.	Number of irrigations.	Depth of water applied during growing of crop.	Total amount applied.
	Feet.					*Feet.*	*Feet.*
Wheat sown in moist soil	0.6	Nov. 26	Mar. 4	Apr. 6	3	1.6	2.2
Wheat sown in dry soil	.....	....do ...	Dec. 8	....do ...	4	2.5	2.5
Wheat sown in moist soil	.6	Dec. 5	Mar. 5	Apr. 11	3	1.5	2.1
Do	.6	Jan. 3	Mar. 7	Apr. 14	3	1.5	2.1
Potatoes	.7	Jan. 9	Mar. 17	May 10	4	1.7	2.4
Do	.7	Feb. 1	Mar. 27	....do ...	3	1.3	2.0
Do	.7	Feb. 22	....do ...	....do ...	3	1.3	2.0
Tomatoes	.6	Feb. 14	Feb. 26	Oct. 28	27	3.7	4.3
Strawberries	.7	Feb. 16	Feb. 16	Dec. 26	36	5.5	6.2
Melons	.7	Mar. 16	Mar. 26	July 8	12	2.6	3.3
Egyptian cotton	.7	Mar. 30	Apr. 11	Oct. 3	13	4.3	5.0
Corn	.6	Aug. 3	Aug. 9	Oct. 7	5	1.5	2.1

[a] McClatchie, Alfred J., Irrigation at the station farm, 1898–1901: Ariz. Agric. Exp. Sta. Bull. No. 41, 1902.

Record of principal crops grown on the farm of the Arizona Experiment Station duri 1901—Continued.

	Date of harvesting.	Yield per acre.	Gross value per acre.	Cost of producing and marketing crop per acre.	Net value per acre.	Net return per foot of water applied.
		Pounds.				
Wheat sown in moist soil..	May 22	2,150	$22.55	$10.25	$12.30	$5.60
Wheat sown in dry soil.....	....do ...	1,850	19.40	9.65	9.15	3.65
Wheat sown in moist soil..	May 24	2,120	22.25	10.20	12.05	5.74
Do.....	May 30	1,920	20.15	9.95	10.20	4.85
Potatoes.....	....do ...	3,200	80.00	35.00	45.00	18.75
Do.....	May 25	3,600	85.00	34.50	50.50	25.25
Do.....	May 30	3,000	70.00	34.50	35.50	17.75
Tomatoes.....	July 1–Dec. 9	12,300	225.00	75.00	150.00	34.90
Strawberries.....	Apr. 15–July 15	5,000	500.00	150.00	350.00	58.45
Melons.....	June 15–July 15	27,000	140.00	26.00	114.00	34.55
Egyptian cotton.....	Dec. 14	400	68.00	48.00	20.00	4.00
Corn.....	Dec. 10	1,735	18.00	9.50	8.50	4.05

LOCATION OF PUMPING PLANTS.

From the information previously given it appears that the best places for pumping plants are in the region south of Tempe where water is but a few feet beneath the surface and on the lowlands along the river in the Phoenix region. Unfortunately the lands upon which pumped water would be most useful do not lie at a lower elevation than the areas where that water is most easily obtained. The elevation of the land to be irrigated therefore enters as an important factor. In order to flow water over a certain tract of land it frequently happens that pumps must be placed on comparatively high land back from the river. The farther a well is from the axis of the gravel beds—not necessarily coincident with the present river's course—the more likely it is to encounter unfavorable conditions.

The irregular distribution of materials in the valley fill gives rise to many annoying surprises in constructing wells. Certain wells have entirely failed where every known condition promised success. On the other hand, wells have been successful in localities which gave little promise. It is obviously impossible to foresee in more than a general way what conditions are to be met with in sinking wells. The figures which follow are diagrammatic illustrations explaining condi-

tions known to exist in Salt River Valley. In fig. 25 let A and B represent two wells with the water standing 20 feet below the surface in each well. Assume (1) that the material in which they are put down is all water-bearing gravel with one-third of the space occupied by water; it is plain then that a lowering of 30 feet, for example, will yield water represented by one-third of the space *a b h f*—the space in heavy lining. (2) Assume that *a g c* is impervious clay and *a c f* is water bearing; then a lowering of 30 feet in either well would yield water represented by one-third of the space *a i h f*—the shaded portion of No. 2. (3) Assume that *a g c* is gravel and the rest clay; then a lowering of 30 feet in well A will yield water represented by one-

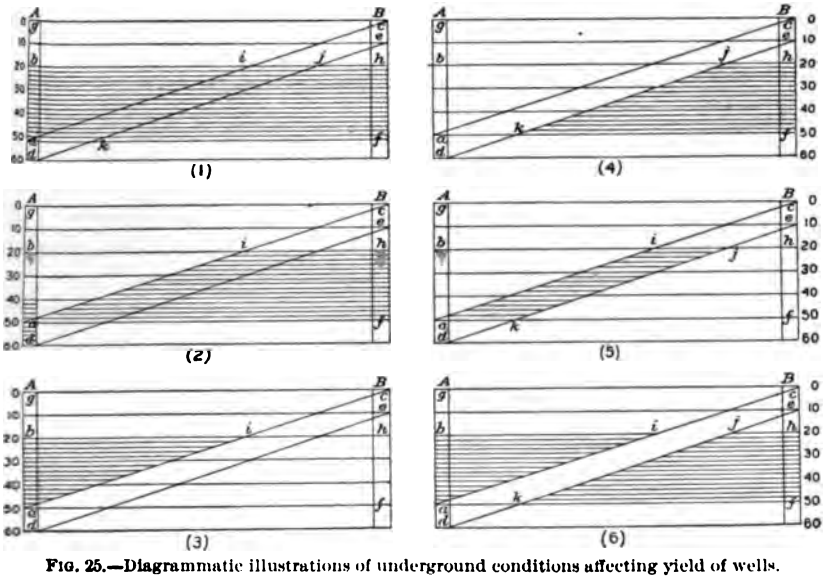


FIG. 25.—Diagrammatic illustrations of underground conditions affecting yield of wells.

third of the space *a b i*, and well B will yield nothing (No. 3). (4) Assume that *d e f* is gravel and the remainder clay; then well A will have no water and well B, in lowering 30 feet, will yield water represented by one-third of the space *k j h f*. (5) Assume that *a c e d* is gravel and the remainder clay; then well B will yield no water and well A only so much as is represented by one-third of the space *a i j k*. (6) Assume that *a c e d* is clay and the remainder gravel; then well A, in lowering 30 feet, will yield water represented by one-third of space *a b i*, while well B will yield water represented by one-third of the space *k j h f;* and the waters may differ in quality as well as quantity.

As a matter of application from the foregoing illustrations it may be stated: (1) That a given set of conditions in one locality will not necessarily be repeated in another, although the two localities are close together; (2) that favorable conditions in one place are not to be interpreted too freely, and, vice versa, that unfavorable conditions in one place are not to be considered entirely discouraging.

RÉSUMÉ.

Some of the more important facts and deductions presented in this paper may be stated as follows:

1. The geological formations which are of most importance in and near Salt River Valley fall naturally in three groups:

(*A*) Pre-Cambrian rocks, consisting of Archean granites and pre-Cambrian quartzites and argillites, in which Salt River Valley was originally formed.

(*B*) Extensive bodies of eruptive rock associated with a limited amount of massive breccia, apparently of Tertiary age.

(*C*) Quaternary and recent formations, consisting of waterworn bowlders, gravel, sand, clay, etc., which partly fill the ancient valley, and are known as the valley fill.

2. The valley fill, at least to a depth of several hundred feet, is regarded as upland or fluviatile accumulation and consists of—

(*A*) River débris, composed principally of waterworn bowlders and gravel of quartzite, quartz, chert, granite, etc.

(*B*) Wash or angular material derived from near-by hillsides.

(*C*) Chemical precipitates, of which caliche is the most important from a geological standpoint. The caliche occurs in more or less impervious layers throughout the valley fill, and serves in many cases to confine the underground water under more or less pressure.

3. The valley fill is not the result of a single period of aggradation. Its accumulation is due to at least two periods of aggradation, perhaps more, separated by a period of degradation.

4. The alternating periods of aggradation and degradation in Salt River Valley correspond with similar periods in other parts of Arizona. Definite correlation of the similar, but widely separated, deposits is impossible at the present time, but uniformity in character and succession over wide areas suggests uniformity of cause.

5. The cause of the accumulation of upland deposits and of the changes from degradational to aggradational condition of streams and vice versa is regarded as due (1) to changes in elevation of the land, and (2) to climatic changes.

6. Salt River Valley is a part of the wide aggraded plain lying southwest of the great continental plateau. Between the plateau and the plain is a mountainous area in which faulting and local crustal movements are numerous. Some of these movements have probably affected Salt River Valley.

7. The isolated peaks and mountain groups in and near Salt River Valley may be due in part to upthrust of crust blocks, but are regarded mainly as remnants of erosion.

8. The plain of which Salt River Valley is a part is due principally to upland accumulations. In the process of accumulation the lowest outlying hills were buried and the higher ones, being only partly buried, are now found rising abruptly from the level plain.

9. The valley fill is saturated with water, and the various beds of gravel are so intimately connected that the water rises to a definite level forming a well-defined water table.

10. During the early part of the accumulation of the valley fill Salt River joined Gila River east of Salt River Mountains, forming in that region the bowlder beds through which the main course of the underflow now finds its way, but at a later stage of the accumulation the river changed to its present course north of Salt River Mountains, forming the uncemented bowlder beds of recent origin, in which the underflow occurs in the Phoenix region.

11. The underground waters are derived mainly from Salt River and to a less extent from the occasional floods entering the valley from the surrounding hills.

12. The valley fill of the Mesa region, to a depth of over 200 feet, consists mainly of river gravels with a subordinate amount of finer material. In the Phoenix region the valley fill consists mainly of fine material with a subordinate amount of river gravels. The river gravels of the Phoenix region occur parallel to the river, and were deposited in a secondary valley, cut in the finer materials of the first period of accumulation.

13. The valley fill is more or less impregnated with various salts derived from the waters of Salt River in former ages and deposited with the detritus.

14. The distribution of the gravel beds and the depth to the water table are such that pumping for irrigation can probably be carried on with profit over an area of 525 square miles.

15. Although some of the underground waters of the valley contain salts in quantities which may be harmful to land under certain conditions, it is probable that with proper manipulation all of the waters can be safely used.

16. The underflow returns in part to the surface in certain places in the valley, making a surface flow estimated as something over 100,000 acre-feet per year.

17. The principal water-bearing horizon is about 15 miles wide in the Mesa region, and extends to a depth of over 200 feet.

18. The quantitative estimate of the underflow, based on experiments, indicates a volume of flow of 148,196 to 287,760 acre-feet per year. At this rate something less than 96 pumping plants of the

average capacity (200 inches) could be operated continuously and retain the water level within pumping distance of the surface.

19. The reserve, or the quantity of water contained in the valley fill at any one time within pumping distance is very much greater than the volume of flow. Conservative estimates place the volume of the reserve of Salt River Valley at from 2,500,000 to 4,000,000 acre-feet.

20. The cost of pumping water in Salt River Valley varies from 5.4 to 13.8 cents per acre-foot per foot of lift, or a cost per acre-foot of pumped water of from $2.50 to something like $5.

21. Since fuel is the great item of cost, the cost could be greatly reduced by the use of electrical power, which might be furnished for about $50 per horsepower per year. At this rate the best pumping plants of Salt River Valley can raise water at a cost of 1.2 cents per acre-foot per foot of lift, or at an average cost per acre-foot of pumped water of something like 75 cents for the present lift.

22. The value of an acre-foot of water applied to irrigation in Salt River Valley varies from $3.65 to $56.45.

23. The volume of underflow is large, but not inexhaustible by the operation of pumps. It is capable of extended development, but there is danger that a greater draft will be made upon it than is consistent with the maintenance of the water level within practicable pumping distance.

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THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
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Correspondence should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

SEPTEMBER, 1905.

2 sheets
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SEPTEMBER, 1905.

Water-Supply and Irrigation Paper No. 137 Series O, Underground Waters, 40

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

DEVELOPMENT OF UNDERGROUND WATERS

IN THE

EASTERN COASTAL PLAIN REGION OF SOUTHERN CALIFORNIA

BY

WALTER C. MENDENHALL

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
Washington, D. C., September 23, 1904.

SIR: I transmit herewith a paper entitled "Development of Underground Waters in the Eastern Coastal Plain Region of Southern California," by Mr. W. C. Mendenhall, and recommend that it be published in the series of Water-Supply and Irrigation Papers.

This report is the first of three papers on the underground waters of the coastal plain of southern California, which are being prepared by the division of hydrology under the general direction of Mr. N. H. Darton. When the series is complete it will contain a list of nearly all the wells in this section of the State, with such data as to water levels, irrigation systems, and irrigated lands as could be collected by a careful canvass.

The studies, a part of whose results are being made available in this way, are planned to cover all the important water-bearing lands of the valley of southern California. In most instances the facts gathered concerning the wells and the distributing systems will be supplemented by a study of the local geology in so far as it controls the amount, distribution, and circulation of the ground waters. The hydrographic data and the geologic data will then be discussed and issued together in one report. In the coastal plain area, however, the geologic conditions being relatively simple, and the hydrographic data being large in volume and of paramount importance, it is deemed best to issue the latter at once, rather than to delay it pending the working out more fully of the comparatively unimportant geologic problems. Therefore the tables and maps are presented here for the consideration of water users, with a comparatively brief text, which is chiefly descriptive, but includes a discussion of the effects of development and drought in bringing about those changes in water levels and in the outlines of artesian areas which have been most marked within the last five or six years.

Very respectfully,

F. H. NEWELL,
Chief Engineer.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

DEVELOPMENT OF UNDERGROUND WATERS IN THE EASTERN COASTAL PLAIN REGION OF SOUTHERN CALIFORNIA.

By W. C. MENDENHALL.

INTRODUCTION.

In California generally, irrigation engineering and water development are further advanced than in any other part of the Union, and in no other part of the State has the scientific study of water conservation, distribution, and application been carried out so fully as in the valley region near Los Angeles. The lands are highly productive when water can be applied to them. The climate is semiarid, with a rainfall of from 10 to 20 inches in the tillable areas, practically all of which is confined to the winter months. This is not sufficient to mature the more valuable crops, hence irrigation must be resorted to, and the extension of the areas of cultivation is dependent upon an increase in the water supply. The flowing waters from the mountain canyons were long ago appropriated, and the attention of irrigators and engineers during the last decade has been turned largely toward the development of the subterranean sources.

As a preliminary step in the study of the amount, availability, distribution and proper use of underground waters, the majority of the wells within the region have been visited. Data have been collected concerning the size, depth, yield, and cost of the wells, and the temperature, purity, and use of the waters. The present and past artesian areas, the irrigated lands, and the main canal systems have been mapped. Outside the artesian belts the ground-water level—the position of the surface of the plane of saturation—has also been determined as closely as possible. In short, the object of the work has been to collect all information which will be of value in the further development of the water resources or which throws light on past development and its effects. It is planned, as the work continues, to examine carefully the general geologic conditions in the water-bearing areas, as the depth, form, storage capacity, and origin of the subterranean reservoirs and the circulation of the waters within them are questions of geology. The extent to which these stored waters may safely be

drawn upon depends upon their amount and the rate at which they are replenished. Some observations on the latter question have been made, and others more extended and systematic have been begun by the Survey.

By the valley of southern California, within which this work is undertaken, is meant that region extending 30 or 40 miles south of the San Gabriel and San Bernardino mountains, and lying between the Pacific Ocean and Cajon and San Gorgonio passes. It includes the greater part of the productive lands of the southern section of the State, and within it lie most of the prosperous settlements which have become famous for their beauty, fertility, and healthfulness.

In the preliminary work on the underground waters within this region the Survey representatives have examined about 11,000 wells of all kinds, from those but a few feet in depth and used only for domestic supply or for stock, to bored wells 1,200 feet deep and yielding in many cases copious flows of irrigation water. The amount of statistical data which has been thus assembled is large, and through the courtesy and interest of water users and irrigation companies is constantly increasing.

The Anaheim and Santa Ana quadrangles,[a] which, together comprise what is called in this paper the eastern coastal plain region, include an area 35 miles long and 15 miles wide, extending from longitude 117° 45′ to 118°, and from latitude 34° to the Pacific Ocean. This area includes the lower portion of Santa Ana River below its lower canyon through the Santa Ana Mountains. The greater part of the San Joaquin Hills are within the Santa Ana quadrangle, and the central part of the Puente Hills are in the Anaheim quadrangle. Between these groups of hills lies the eastern end of the southern California coastal plain, including a part of the famous peat lands of Orange County, and the perhaps equally well-known agricultural lands about Santa Ana, Orange, and Anaheim. Under these lower, comparatively level lands the important underground waters are found. The artesian basin of the coastal plain, the largest artesian basin in southern California, with an area of about 190 square miles, occupies the northwestern portion of the Santa Ana quadrangle, and extends along the western edge of the southern half of the Anaheim quadrangle. A broad zone, originally artesian, but not now yielding flowing water, stretches across the southwestern corner of the Anaheim quadrangle. Within this zone water lies within easy pumping distance.

[a] A quadrangle is the unit of survey adopted by the United States Geological Survey for the topographic and geologic atlas of the United States. It is a rectangular area 15 minutes, 30 minutes, or 1 degree in extent each way, bounded by parallels and meridians, and having an area of one-sixteenth, one-quarter, or one square degree. The quadrangles disregard political boundaries, such as those of States, counties, and townships. To each is given the name of some well-known place or feature within its limits. A sheet is the topographic map of one of the above areas.

COASTAL PLAIN.

The coastal plain, of which the lowlands in these two quadrangles form a part, extends from the Pacific to the base of the Puente Hills and the Santa Ana Mountains, and from the Santa Monica Mountains to the San Joaquin Hills. It is about 50 miles long and from 15 to 20 miles wide, and has an area of approximately 775 square miles. It is generally a smooth plain with an elevation along its inland edge of from 200 to 300 feet, from which it slopes gently to sea level at the coast. San Pedro Hill rises well above it, and its general regularity is interrupted by a long low ridge which extends from the vicinity of Palms to Huntington Beach. This ridge is not continuous, as a wide valley has been cut through it by each of the larger streams which flow across the coastal plain to the sea, thus breaking it into a series of detached but aligned hills of different heights. This broken ridge forms the seaward boundary of the coastal plain artesian basin. Within the area treated in this paper it is a rather inconspicuous physical feature, existing as the low, broad mesa about Huntington Beach, and perhaps as the similar feature north of Newport and enveloping the base of the San Joaquin Hills.

The coastal plain is underlain by a succession of sand, gravel, and clay beds whose constituent materials were transported to their present position by Santa Ana, San Gabriel, and Los Angeles rivers, and perhaps in small part by the waves and currents of the Pacific. This plain represents a former wide bay which was gradually filled by alluvial débris that has been redistributed, in part at least, by oceanic waters as beach sands and gravel. Convincing evidence of this factor in distribution is furnished by the recent marine shells which are so often found in deep and shallow wells and on the present surface some miles from the shore line.

CROPS.

Within the area under consideration crops and soils are varied, as is generally true throughout the coastal plain, and irrigation practice is not at all uniform. In the Anaheim quadrangle about Orange, Fullerton, and Anaheim are many citrus groves, and deciduous fruits and walnuts are extensively cultivated. Farther south, in the peat lands, celery is becoming a more and more important crop, and sugar beets, corn, and alfalfa are extensively grown.

The citrus groves require the regular application of water throughout the year, irrigation being constant, except when winter rains are sufficiently heavy to serve as a substitute. Practice is not uniform in the walnut groves, some growers maintaining that irrigation is not necessary. This may be true in moist lands, where the roots can reach the ground waters, but generally ranchers find it profitable to apply

water during the summer season. Deciduous orchards, generally in the lower lands, are under irrigation, but in the vicinity of La Habra are a number of flourishing groves which receive only the rainfall.

In preparing the peat lands for celery the soil is thoroughly flooded and often water is turned on again once or twice before the crop matures, but in the moister lands one or both of these later applications may be omitted. With sugar beets, also, practice varies. Water is almost invariably used in preparing the land, and is often, but not always, applied during the growth of the crop. Corn, alfalfa, potatoes, and peanuts are usually irrigated, while grapes and barley are sometimes watered during dry years, but these, with beans, are regarded as the principal dry crops.

On many of the lands which lie under the Santa Ana Valley or Anaheim canal systems, as well as on those watered from pumping plants, a certain amount of rotation is practiced, and lands which are irrigated one year may stand dry during another or may be planted to a crop requiring much more or much less water than the one grown during the preceding season. This is possible only with the annuals, of course. Groves or other crops requiring more than one year to mature can not be rotated in this way. These variations in crops and in irrigation practice make it difficult to estimate the duty of water per acre of irrigated land. Citrus lands are regarded as requiring an equivalent of approximately one miner's inch[a] continuous flow for each 5 acres. Other crops require less, some of them very much less.

The total area irrigated during the season of 1904 in the Anaheim quadrangle is estimated at 28,800 acres and in the Santa Ana quadrangle at 6,600 acres, a total of 35,400 acres.

In this estimate of the total acreage irrigated, and on the maps showing irrigated lands (Pls. II and III), those areas upon which water is applied in the manner known as "subirrigation" are not included. Subirrigation consists essentially in releasing the water on the surface or in ditches which are widely separated, whence it seeps laterally for long distances through the fine sandy subsoil which is under much of the peat lands. The method is applicable only where the water table lies near the surface. It amounts in effect to raising this water table locally, so that it may be reached by the roots of grasses, corn, beets, and other plants with short root systems. It is not possible to map the areas irrigated in this way or to estimate their amount, because the boundaries are wholly indefinite and the lands thus watered are often inseparable from those which are naturally moist enough to mature crops. This method is applied more generally to pasture lands than to cultivated areas.

[a] Wherever the term "miner's inch" is used in this report the old California miner's inch is meant. This unit is the amount of water that flows through a 1-inch orifice under 4 inches pressure. It is equal to 9 gallons a minute, one-fiftieth of a second-foot, or 14.478 acre-feet a year.

IRRIGATION SYSTEMS.

Three streams supply surface irrigating waters for the Santa Ana and Anaheim quadrangles. These are San Gabriel River, from which water is brought to a territory east of Whittier, in the La Habra district; Santa Ana River, in which the important Anaheim Union and Santa Ana Valley systems originate; and Santiago Creek, which supplies the Serrano and Carpenter ditches, in the vicinity of Villa Park and El Modena.

SAN GABRIEL SYSTEM.

LA HABRA AND EAST WHITTIER WATER COMPANY.

The La Habra and East Whittier Water Company procures water from the San Gabriel Valley, above the Paso de Bartolo, by means of a battery of wells and pumps. The water is discharged into an old

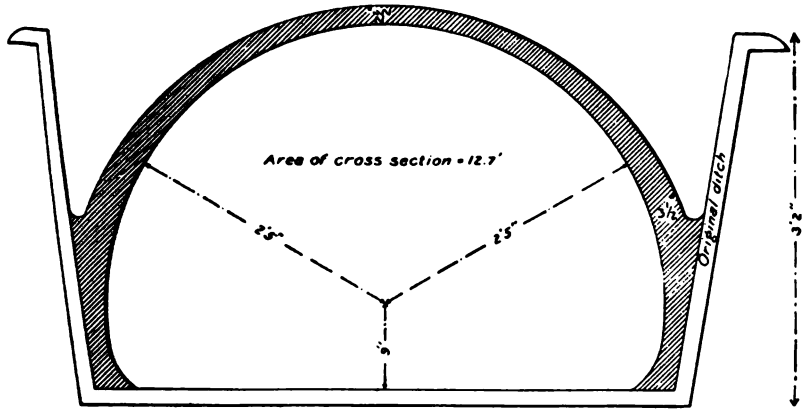

FIG. 1.—Cross section of East Whittier ditch.

ditch which has been covered with concrete and so converted practically into a pipe line (fig. 1). This line extends to Pickering avenue, Whittier. From Pickering avenue to the La Habra pumping station the water flows through a 36-inch wooden pipe line. From the pumping station about 3,300 feet of 26-inch steel pipe is used for the lift of 110 feet to the reservoir above. A 120-horsepower steam pump has been installed for this lift.

From this reservoir about 6,000 feet of cement pipe extends to an arroyo southeast of the pumping station, and a 24-inch concrete pipe runs from this point to the center of sec. 5, T. 3 S., R. 10 W. A 22-inch pipe extends thence to the reservoir and pumping station on the west line of the Rancho San Juan Cajon de Santa Ana. From this station a lower 22-inch gravity line extends to the east side of Brea Canyon, and a line about 2,000 feet long, with a lift of 66

feet, extends to a distributing box above the pumping station, whence a distributing pipe, in part steel, extends eastward to beyond Brea Canyon.

From the La Habra station the California Domestic Water Company has a gravity line running southward for 2 or 3 miles toward Coyote Creek and serving the adjacent lands.

SANTA ANA SYSTEMS.

All of the water flowing in Santa Ana River at Bedrock Canyon, 4 miles west of Rincon, where its flow is supposed to be at a maximum, is taken from the river bed and divided equally between the Anaheim Union Water Company, which supplies the lands north of the river, and the Santa Ana Valley Irrigation Company, which serves the lands south of the river.

A division box of wood, supported by piling, has been built at Bedrock Canyon. One-half the water of the river is diverted here into the Anaheim Union Water Company's canal; the other half, after the division, is returned to the river bed, and is taken out again at the headworks of the Santa Ana Valley Irrigation Company's canal 3 miles below.

ANAHEIM UNION WATER COMPANY.

According to the report of William Ham. Hall, formerly State engineer of California, the Anaheim Union Water Company is the successor to the earlier rights held by the Anaheim Water Company, the Kramer ditch, and the North Anaheim Canal Company and its predecessors, the Cajon Irrigation Company and the Cañon de Santa Ana Water Company.

The Kramer ditch was the oldest of the water rights acquired. It had taken water from the river several years before the founding of Anaheim in 1857, and had used those waters to irrigate the Kramer tract. For its rights, the Anaheim Union Water Company gave 20 shares of nonassessable stock.

The Los Angeles Vineyard Society, organized in 1856, secured 1,165 acres of land from the Rancho San Juan Cajon de Santa Ana and a water right based on the riparian rights of the rancho. It built a ditch and diverted sufficient water to irrigate nearly 2,000 acres. In 1860 all the water rights, ditches, canals, and rights of way belonging to the society were conveyed to the Anaheim Water Company.

The Cajon Canal was begun in 1875, under the authority of the Bush act of 1874, which provided for the organization of irrigation districts in Los Angeles County, under the supervision of a county superintendent of irrigation.

District No. 1 was organized and built a small ditch, about 3 feet wide on the bottom, to the mouth of the canyon; District No. 2, formed

A. AN UNCEMENTED PORTION OF THE UPPER ANAHEIM CANAL.

B. A CEMENTED PORTION OF THE UPPER ANAHEIM CANAL.

later, joined the first district and the canal was enlarged to its present size. After an expenditure of $40,000 the work was abandoned.

In 1876 the Stearns Rancho Syndicate organized the Cañon de Santa Ana Water Company, with a capital stock of $200,000, and took possession of the canal. No work, however, had been done at the end of two years.

In 1877, seven landowners organized the Cajon Irrigation Company with a capital stock of $20,000. They filed on 4,320 miner's inches of water at the head of the partly completed Cajon canal, took possession adversely to the claim of the Cañon de Santa Ana Company, and brought suit to quiet title. The suit never came to trial, but possession on the part of the new company was never strongly resisted by the older, less active organization.

The stockholders of the new company, although not wealthy men and having a hard struggle to raise the necessary means, managed to continue construction upon their canal. At the time when they were most deeply involved, they sold one-half interest to the Anaheim Water Company for $20,000, and with these funds continued the work. In 1882, because of defects in their original organization, they reorganized, taking the name of the North Anaheim Canal Company, whose rights had been purchased for $500 in 1878. This last-named company was organized in 1872 to irrigate land northwest of Anaheim. Its ditch, with a capacity of 1,500 miner's inches, rarely received water except in winter.

The joint ownership of the Cajon canal by the Anaheim Water Company and the Cajon Company was never a satisfactory arrangement. Disagreements about the division of water led to lawsuits, and in 1884 a consolidation, resulting in the formation of the present Anaheim Union Water Company, was effected.

Under its present organization, which was completed in January, 1884, the $1,200,000 capital stock of the company is divided into 12,000 shares, of which 8,004 shares, representing 8,004 acres under irrigation, have been sold, the balance being held as treasury stock. The par value of the stock is $100 a share, and the present (1904) market value is about $65 a share. Stock in the water company is not appurtenant to the land, but may be bought or sold independently.

The main canal, of cement or earth construction, has a capacity of about 26 heads of 100 miner's inches each. The minimum supply is given as about 800 miner's inches. Hall gives the length of the main canals and branches as over 100 miles, and the officers of the company state that about 35 miles of laterals are cemented. (See Pl. IV.)

One share of stock entitles the owner to one head of 100 miner's inches for one-half hour during each run throughout the summer season

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of minimum supply. When water is abundant there is no time limit, and all the water that the irrigator desires to purchase may be taken out. The water to which ownership of stock entitles the holder is paid for at present according to the following schedule:

Charge for water under canals of Anaheim Union Water Company per head of 100 miner's inches per hour.

November, December, January, and February	$0.30
March	.40
April and October	.50
May and September	.60
June, July, and August	.80

In addition to these payments for water, assessments are made each year to pay interest on debt and to make improvements. Of late years these assessments have averaged about $3.50 per year per share.

SANTA ANA VALLEY IRRIGATION COMPANY.[a]

The water rights of the Santa Ana Valley Irrigation Company, which serves the greater part of the irrigable lands south of Santa Ana River as far as Santa Ana and Tustin, are based on the riparian rights of the Rancho Santiago de Santa Ana to one-half of the water of Santa Ana River.

When this ranch was partitioned among its owners by decree of the court in 1868, each owner was given the right to divert from the river his share of the water for irrigation. A number of ditches were constructed from time to time on the basis of this right, the majority of them being afterwards abandoned. The rights of one of these were secured by the Chapman ditch, which was extended as far as Orange in 1871. In 1873 it was sold to the Semi-Tropic Land and Water Company and extended to Santa Ana and Tustin. This ditch and the Watson ditch, which it supplied, diverted one-half the waters of the river; the other half, which belonged to the irrigators north of the river, was in large part lost in the sandy bed of the stream before reaching the head of the Anaheim ditch. The result was a shortage of water on the lands served by the Anaheim ditch, and a suit was begun against the Semi-Tropic Water Company to establish the right of the Anaheim ditch to water amounting to its full capacity. In the lower court the decision was against the Semi-Tropic Company, but in an appeal this decision was reversed, the case remanded for trial, and a recommendation made by the court that the litigants agree upon an equal division of the water. This recommendation was accepted, litigation ceased, and the south-side irrigators have since held undisputed possession of one-half the flow of the river.

[a] The sketch of the earlier history of this organization, as of the Anaheim Union Company, is condensed from "Irrigation in California," by William Ham. Hall.

A. MAIN SANTA ANA CANAL ABOVE BURRUEL POINT.

B. CREST OF SUBMERGED DAM AT POINT OF ROCKS, SANTIAGO CANYON.

In 1877 the Santa Ana Valley Irrigation Company was incorporated with a capital stock of $100,000, divided into 20,000 shares. Its object was to extend the benefits of irrigation to the 20,000 acres of the original rancho entitled to water. Improvement of the original system was immediately begun and has been gradually extended until now the greater part of the main canal and laterals are cemented, and excellent service is rendered.

Of the 20,000 shares, 16,055 are sold, the balance remaining in the treasury. The par value is $5 per share; but as all assessments are added to the cost of shares, and as the value of the property has increased, these now (1904) have a market value of about $60.

The stock is appurtenant to the land, and may not be sold independently of it. Each share entitles the holder to 1 head of 100 miner's inches of water for a half hour each run during periods of scarcity and for an hour during ordinary periods. When water is abundant the irrigator may use all the water he wishes by paying the current rates. These rates are, during the day, 20 cents per 100 miner's inches per hour; during the night, 10 cents per 100 miner's inches per hour.

The company is well managed, has a small debt, and its system is in splendid condition. Service is rendered at a very low rate. The main canal (Pl. V, *A*) extends from the intake in the lower canyon of the Santa Ana to Burruel Point, a distance of about 9 miles. More than half of this canal is cement lined, with an average width at bottom of 12 feet, a depth of 5 feet, and a width at top of 22 feet. Its capacity is about 7,000 miner's inches. Below Burruel Point the main canal is divided into an upper and lower canal, from which a complete system of laterals forms a network through the country served. The principal laterals, as well as the main lines of the system, are shown on Pl. II.

SANTIAGO CANYON SYSTEMS.

Two small but efficient and interesting irrigation systems are served by the waters of Santiago Canyon.

At a narrow point in the canyon, known as the Point of Rocks, about 2½ miles above Villa Park, a very successful submerged dam (Pl. V, *B*) has been built across the channel of the stream. It extends from rim rock to rim rock, a distance of 110 feet, and has a maximum height, where the channel is deepest, of 19 feet. At this point its width on the bottom is 12 feet. It has a uniform width at the top of 3½ feet along its entire length. An earlier clay dam had been built at the same point, but after its partial destruction by floods the present rock and concrete structure was built in 1892 by the Serrano and Carpenter associations, jointly, at a cost of $3,700. All of the underflow of Santiago Creek at this point is forced to the surface, and as a result a continuous flow of 40 or 50 miner's inches is maintained throughout

the dry season. Some distance above the dam, in the valley of Santiago Creek, a reservoir of earth and sand is filled by the winter floods and is allowed to drain slowly away by seepage into the gravels of the creek bottom during the succeeding dry months. This helps to maintain the summer flow over the surface of the submerged dam. Without these inexpensive but most successful works all of the summer flow of Santiago Creek, during dry seasons at least, would escape by subsurface percolation.

From the submerged dam (Pl. V, *B*) the water is conducted along the south bank of Santiago Creek for 750 feet in a 28-inch cement pipe to a division gate, where it is divided equally between the Serrano and Carpenter companies, operating on the north and south banks of Santiago Creek, respectively.

SERRANO WATER COMPANY.

The Serrano Water Company's right dates back to an appropriation of one-half the waters of Santiago Creek by Bush and Watson in 1872. This right was later transferred to others, and in 1876 the Serrano Water Company was organized by J. O. and R. F. Lotspeich and five others, who held the right at that time.

Previous to 1879 the water was diverted by primitive dams into earthen ditches, but during that year a submerged dam of clay was constructed to bed rock and a cement distributing pipe laid from the dam to the lands served. In 1892, the older dam having been partly destroyed by flood, it was replaced by one of rock and cement, which is still in use. From the division gate below this dam the Serrano Company has 3,200 feet of 20-inch cement pipe to a division gate between the two tracts known as the Lotspeich and Grey tracts, served by this association. On the Lotspeich tract are about 3 miles of cement pipe from 10 to 16 inches in diameter, and on the Grey tract are about 1½ miles of similar pipe. In addition, the final distribution on a portion of each tract is made by open ditches. The association has 70 members and serves 1,303 acres. The water is apportioned to each member in proportion to his acreage, and runs through in 18½ days.

CARPENTER WATER COMPANY.

October 1, 1872, John F. and Alexander Carpenter entered upon and appropriated one half the water of Santiago Creek, the other half having been appropriated by Bush and Watson at an earlier date. J. F. Carpenter built the first ditch soon after his purchase, and conveyed his land and water rights to Oge and Bond in 1874. About 1881 the first pipe line of 10 and 12 inch cement pipe was constructed. It was extended in 1883 to the Santiago Land and Water Company's reservoir north of El Modena.

This original pipe line gave unsatisfactory service because of its small capacity, and in 1902 a new line was laid at a cost of $8,000. It consists of 2,400 feet of 20-inch cement pipe, 3,600 feet of 18-inch cement pipe, and about 9,000 feet of 16-inch pipe.

This company, unlike the Serrano Association, was incorporated in 1901, the stock being divided into 1,600 shares, at a par value of $10 per share. One thousand shares are distributed, and the remainder is held as treasury stock. The shares may not be sold except with the land.

When the water is low each irrigator uses the entire supply for 16½ minutes for each acre irrigated. At this rate it takes 18½ days to make a "run;" that is, to water once all of the lands under the pipe lines. When water is more abundant the lands served are divided into two or three sections, which are served simultaneously, and use the water for 33 or 49½ minutes per acre each, so that a run as before requires 18½ days, but each irrigator gets two or three times the amount of water that is served him when the supply is low. The light running expenses are provided for by annual assessments on the stock.

The title to the waters of Santiago Creek for irrigation purposes, as vested in the Carpenter and Serrano companies, was fully confirmed in a decision rendered June 1, 1896, in the superior court of Orange County, in which the owners of Rancho Lomas de Santiago were perpetually enjoined from using the waters, except for domestic purposes or for stock.

Both the Serrano and Carpenter companies are models of efficient and economical construction and management.

DRAINAGE DISTRICTS.

The reclamation of the peat lands in the western part of the Santa Ana quadrangle and in adjacent quadrangles to the west has been a problem of drainage rather than of irrigation. As these lands are generally nearly flat for long distances, or at best have a very gentle if uniform slope toward the coast, it has not been practicable for an individual farmer or ranch owner alone to undertake drainage. Successful ditches must be extended to the tidal sloughs to secure an outlet. This has often meant some miles of construction, and has necessitated cooperation on the part of the benefited landowners. The lands of the district are dark, especially fertile soils, enriched by vegetable mold. Without artificial drainage they are generally too damp for cultivation, since they include the lowlands along the lower course of Santa Ana River and overlying the lower edge and most effective portion of the artesian basin. Strong springs, representing leakages from the artesian waters below, are found at a number of points. The flow from these has kept the lands about them saturated

even during the dry season, and the first and most important problem has been to provide for the free escape of these spring waters.

Under a State law, passed in 1897, two drainage districts have been organized, each with its governing board of three directors, who properly apportion the expenses among the landowners benefited. The assessments for the maintenance of the systems are determined by these directors, the county collects them with the other taxes, and warrants are then drawn upon the county treasurer for expenses incurred in construction and maintenance.

BOLSA DRAINAGE DISTRICT.

Only a part of the Bolsa drainage district, the older of the two organizations, is in the Santa Ana quadrangle. It includes the region about Smeltzer and Celery and an area to the west in the Los Bolsas quadrangle.

The earliest ditch in this district is said to have been begun by the Stearns Rancho Company many years ago. Later the county extended the original Bolsa ditch, and finally, in 1899, the Bolsa drainage district in its present form was organized. It includes about 2,400 acres, and perhaps 15 miles of ditch have been dug. The network of ditches is being slowly extended, and much tile underdrain with outlets in the main ditches is being put in by ranchers. Maintenance is said to cost about $1,000 per year, and an additional sum is spent each season for new construction.

WILLOWS DRAINAGE DISTRICT.

The Willows drainage district was finally organized, after several unsuccessful attempts, during the spring of 1904. It includes an area of about 9,000 acres, centering about the village of Talbert. A number of old ditches, built by individual or community effort and varying in length and character of construction, are included in the district as now organized. One of the most important of these is the Willows ditch, dug in 1899 by Messrs. Lamb, King, Newland, and Bourchard. It is about 6 miles long, 6 or 7 feet wide, and 3 or 4 feet deep. It cost about $1,800.

The Lamb and Bourchard ditch was begun as a small ditch in 1875. In 1898 it was enlarged and extended, and is now about 3½ miles long, but of varying width and depth. The Newlands ditch is about 3½ miles long, 6 feet wide, and 3 feet deep.

The district at present includes about 20 miles of canals, but has been bonded for $20,000; $10,000 of the bonds are being sold and with the proceeds it is planned to perfect and extend the present system until about 28 miles of main canals are constructed.

The lands reclaimed by these systems are proving to be among the richest and most valuable in this part of the State.

UNDERGROUND WATER.

SOURCE.

The sands and gravels that underlie the coastal plain are saturated, from a point whose distance below the surface varies with locality, to bed rock, which lies at an unknown depth. The water has been supplied chiefly by the large streams that flow across the coastal plain and derive their supply from the higher mountains, where precipitation is greater and direct evaporation less than in the lowlands.

The amount at present stored in these gravels represents slow accumulation through long periods. Even through the summer it without doubt receives accessions from the underground flow of the larger rivers, from slow drainage of the slopes of neighboring hills, and from return waters from irrigation; but these contributions must be very small as compared with those received through the absorption of flood waters and direct rainfall during the winter. The winter accessions are received mainly along the inner edge of the coastal plain, where the rivers first discharge upon it, and where its sands and gravels are coarser; hence the saturating water must move slowly seaward at varying rates, which depend upon the coarseness of the medium through which it is percolating. Some of it passes beneath the clay beds which alternate with the sand and gravel in the flatter lower portions of the coastal plain and dip with the general surface toward the sea. The water beneath such a sloping, impervious clay bed finds its exit along the lower edge of the bed, but, checked by the increasing imperviousness of the stratum through which it is passing, or by a fold in the beds, or by an earlier ridge against which they abut, accumulates head and flows at the surface of the ground when the overlying confining mass is pierced by a drill. This is the general explanation of the artesian conditions which prevail here. North of the artesian belt the ground water is found at a depth which usually increases inland from the artesian area toward the hills. Near the hills it may lie at depths which preclude pumping at a profit for ordinary crops. South of the artesian area the depth of the ground-water level varies with the topography, being least in the lowest lands and greater in those which are higher.

The ground waters which are not artesian have precisely the same origin as those which exist under pressure. Indeed, they are part of the same subterranean water body, due to rainfall, in part local, in greater part run-off from the higher mountain areas which surround the valleys, whence they flow to the lowlands as winter flood waters.

PERMANENCE OF THE UNDERGROUND WATER SUPPLY.

The decade of dry years through which southern California has passed seems likely to have brought the flow of surface streams down to a minimum, so that those irrigators who depend on the surface

flows and have adjusted themselves thoroughly to this determined minimum have no ground for further concern as to their supply, provided their rights are so thoroughly adjusted legally that rivals can not enter the field and, either by surface diversions or by the installation of wells and pumps, either above or below them, divert their waters.

The supply derived from underground sources is in a less stable and well-adjusted condition. The underground reservoir, which lies along the coastal plain and furnishes the subterranean waters used in the Anaheim and Santa Ana quadrangles (see Pls. VI and VII), is by far the largest and has much the greatest capacity of any in southern California (see Pl. I). It is fed by the flood waters and, to a much smaller degree, by the underground seepage of the three most important streams in this part of the State—Los Angeles, San Gabriel, and Santa Ana rivers. Other less important accessions to its supply are local rainfall, minor drainage from adjacent hills, and return waters from irrigation.

The three largest streams named above, which form the main source of the underground waters, are somewhat less efficient now as agents for the replenishment of the underground supply than before the settlement of the country. All of their normal flow, for some years, has been diverted before it reaches the coastal plain, and an important percentage of the minor floods is used by irrigators along the upper parts of the streams. Only the greater floods reach the lower stretches, and of them a somewhat smaller percentage than formerly escapes absorption by the alluvial fans just below the canyon mouths, because the absorptive capacity of the fans has been increased by their drainage in the search for water for irrigation. The accretions from local rainfall and minor undiverted drainage from near-by hills have not been affected by settlement. They depend upon annual precipitation and vary with it. The accretions from return irrigation waters furnish a source which did not exist before the colonization of the region, but as these are a variable and probably generally a small portion of the extra drafts which man has made upon the underground supply, either by drawing directly from it or by diverting stream waters which would otherwise be added to it, they serve only to reduce slightly the effect of these drafts.

The sum of all these effects must be a notable decrease in the amount of water annually added to the underground reservoirs. Meanwhile there have been extensive drafts made upon them, and these drafts are constantly increasing. There are nearly 3,000 wells in the area under discussion and over 8,000 in the entire coastal plain belt. Of the former, 800 were flowing wells in the spring of 1904, 400 were equipped with power pumping plants, and nearly 900 had windmills over them.

The remainder were domestic wells, whose drafts upon the underground supply are inconsiderable. In the two quadrangles under discussion the total output from the wells that could be measured, or whose owners could furnish definite data as to the yield, amounts to 240 second-feet during the pumping and irrigating season. These figures include the yield both of artesian wells and pumping plants. The pumping season varies with the crop and the rainfall, but usually lasts from fifty to one hundred days. Many of the artesian wells are open the year round, others are capped when not in use, and since in the above computation there were omitted all wells which yield less than 1 miner's inch, all natural springs, of which there are several with a large yield, and a great number of artesian wells which for one or another reason were not accessible for measurement, it is considered well within the truth to estimate the draft of 240 second-feet as continuous for two to three months in the year, equivalent to an annual draft of 40 to 60 second-feet, upon the underground supplies.

The amount of annual withdrawals from underground sources may be estimated in another way. The total area under irrigation on the two quadrangles is about 35,000 acres. On the basis of a duty of 1 miner's inch to from 7 to 10 acres, continuous service, from 70 to 100 second-feet of water would be required for this acreage. As the minimum supply received in this area from the Santa Ana, the San Gabriel, and Santiago Creek is from 30 to 40 second-feet, this estimate leaves 40 to 60 second-feet to be supplied by the underground sources. Neither estimate is very accurate, but as the two are in accord the result may be accepted as being approximately correct.

This means that the water which is being drawn from the underground reservoir in the Santa Ana and Anaheim quadrangles is equal to from one to one and one-half times the minimum flow of Los Angeles River at the headworks of the city canal, or of Santa Ana River at Bedrock Canyon, where the diversion works of the Anaheim and Orange systems are located.

It is estimated that $250,000 is already invested in pumping plants, and the number of these is increasing as rapidly as the machinery can be secured. Many owners of stock in the Anaheim Union Water Company have disposed of their stock and depend upon the underground supply entirely.

The number of wells within the present artesian belt (see Pls. VI and VII) is being rapidly increased also, and with the decrease in pressure and the falling water plane some lands must be irrigated which formerly were sufficiently moist to mature crops without irrigation.

Here, as in other parts of southern California, the effect of the low rainfall of the last decade and the constantly increasing drafts upon the stored waters, is shown in a decreased flow in the artesian wells, a shrinkage of the artesian area, and a lowering of the water table outside of it. The original area of the coastal plain artesian belt was nearly 300 square miles; the present area is less than 200 square miles (Pl. I). Originally, there were about 36 square miles of artesian water-bearing lands in the Anaheim quadrangle; now there are only about 4 square miles in which the water flows (Pl. VI). In the Santa Ana quadrangle the loss has been less because this quadrangle includes the lower and more favorably situated portion of the artesian belt. The original

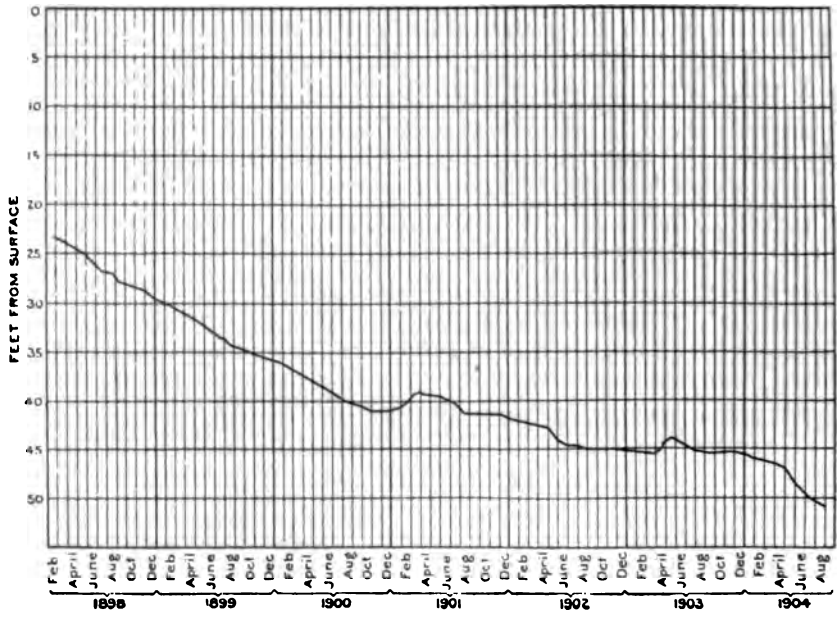

FIG. 2.—Diagram showing variation in water level near Anaheim.

area here was about 70 square miles, and the present area is nearly 57 square miles (Pl. VII).

The effect on the water plane outside of the artesian area is graphically shown in the accompanying profile (fig. 2) which has been prepared from a systematic series of measurements made by Mr. J. B. Neff, on the water level in the wells near Anaheim from which he draws his irrigation water. March 1, 1898, the surface of the zone of saturation in these wells stood 23 feet below the land surface. From this time through the remainder of the dry period, lasting until the fall of 1900, the decline was continuous and very regular, averaging between 6 and 7 inches per month The moderately heavy rainfall of

ceeding winter (1900–1901) raised the level 2 feet, but the gain st by the middle of the following summer, and the decline con- at varying rates until April 1, 1903. During April and May ter level rose 1½ feet, but quickly fell about to the point at it stood before the spring rains. This level was maintained anuary 1, 1904. Since then the water has gone down rapidly e of the dry winter of 1903–4, and the rapid increase in the num- pumping plants, until, on August 1, 1904, it was more than 50 low the surface, an average decline of over 4 feet per year since ations began.

Rainfall, in inches, at Anaheim, Cal.

ar.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.
.....	0.00	0.00	0.00	0.15	T.	0.95	1.96	0.57	0.35	0.37	T.	0.00	4.35
.....	.00	.00	.00	.11	1.72	3.10	1.29	1.32	1.57	2.20	0.00	.00	11.31
.....	.00	.00	.00	.28	.44	4.92	.25	.28	.85	.06	.00	.00	7.08
.....	.00	.00	.00	.81	.34	.37	.40	1.90	2.42	.48	.40	.00	7.12
.....	.00	.00	.00	.26	.78	.00	1.48	1.98	1.22	0.10	2.78	.00	8.60
.....	.00	T.	.00	1.12	.00	1.40	2.80	10.58	6.70	1.75	.54	1.28	26.17
.....	.00	.00	.00	.15	.64	3.72	.61	.00	.00	.64	.00	.00	5.76
.....	.00	.00	.00	T.	2.93	1.16	4.63	.82	2.70	2.51	00	.00	14.75
.....	.00	T.	.00	.00	.33	T.	.43	5.71	.00	2.21	T	.00	8.68
.....	.00	.00	T.	.75	.92	2.16	6.29	.92	5.90	T	00	.00	16.94
.....	T.	.00	.00	T.	3.75	4.19	.14	1.28	7.97	24	.57	.00	18.14
.....	.00	T.	.76	2.31	.30	10.95	3.36	1.54	.78	00	T	.00	20.00
.....	.00	.00	.29	.00	.19	3.35	.24	9.05	.59	1.81	.40	.00	15.93
.....	.00	.00	.00	.00	.00	1.44	.77	2.35	1.23	15	48	.00	7.42
.....	.00	.00	.00	.19	.94	1.48	2.98	2.06	6.07	23	00	.00	13.95
.....	.00	.00	.00	.00	.30	2.38	.68	.35	.48	13	10	.00	4.42
.....	T.	T.	.10	.00	.00	5.69	6.92	.68	2.63	05	10	.00	16.07
.....	.00	.00	.00	.00	.97	.48	3.25	.00	3.03	T	00	.00	7.73
.....	.00	.00	.00	1.98	1.40	1.59	3.00	4.35	2.20	00	.00	.00	14.52
.....	.00	.00	.10	1.60	.00	.00	1.65	.10	1.00	20	1.00	.00	5.65
.....	.00	.00	T.	.00	.00	.20	2.78	.15	1.61	20	00	.51	5.25
.....	.00	.00	.07	1.32	.84	1.45	1.29	.00	.73	1.09	1.49	.09	8.37
.....	.00	.00	.00	.31	4.81	.00	3.50	3.11	.59	T.	2.30	.00	14.65
.....	.00	.00	.00	1.34	.50	.00	1.70	3.16	3.20	.11	.07	T.	10.08
.....	T.	.00	.00	.40	1.36	3.83	1.22	2.61	5.58	4.47	.00	.00	19.47
.....	.00	.00	.38	.06	.00	.00	.19	1.39	3.61	.82	(?)	.00	6.45

ge, 26 years, 11.45.

Rainfall, in inches, at San Bernardino, Cal.

Year.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Tot
1870-71	0.00	0.00	0.02	0.09	3.11	0.89	6.91	2.21	0.19	0.34	0.11	0.07	13.
1871-72	.00	.04	.13	.60	.88	3.91	.00	2.20	.37	.79	.06	.00	8.
1872-73	.00	.18	.04	.00	1.17	4.40	6.50	1.25	.51	.84	.21	.00	15.
1873-74	.00	1.06	.02	.01	.74	5.73	5.51	8.76	1.08	.48	.42	.00	23.
1874-75	.00	.00	.06	1.82	1.88	2.20	7.20	.15	.22	.07	.05	.00	13.
1875-76	.00	.00	.00	.00	7.50	.02	6.55	1.92	3.41	.44	.03	.03	19.
1876-77	.00	.00	.00	.20	.40	.00	3.50	4.03	.83	.26	.30	.00	9.
1877-78	.00	.00	.00	.86	.50	3.95	3.33	6.68	2.57	1.71	.66	.07	20.
1878-79	.07	.00	.02	.14	.05	4.70	3.59	1.00	.50	1.20	.24	.03	11.
1879-80	.11	.02	.01	.94	3.40	6.50	1.56	1.33	1.45	5.00	.04	.00	20.
1880-81	.00	.00	.00	.14	.67	8.80	1.40	.36	1.66	.46	.01	.00	13.
1881-82	.00	.00	.00	.80	.27	.50	1.11	2.65	3.30	2.91	.00	.00	11.
1882-83	.00	.00	.00	.10	.15	.45	1.60	1.10	2.82	2.95	.00	.00	9.
1883-84	.19	.00	.53	.85	.09	2.63	1.63	12.20	9.95	5.68	3.17	.59	37.
1884-85	.00	.00	.00	.00	.11	3.75	2.79	.11	.28	1.89	1.69	.19	10.
1885-86	.00	.00	.00	.39	4.36	1.20	6.34	2.52	4.18	2.36	.32	.16	21.
1886-87	.00	.00	.00	.00	.11	.61	.39	6.44	4.41	1.90	.42	.22	14.
1887-88	.11	.04	.09	1.17	2.29	1.91	4.01	3.60	3.41	.58	.52	.03	17.76
1888-89	.00	.00	.00	.05	4.12	4.64	.93	1.50	6.55	2.05	1.13	.00	20.97
1889-90	.17	.63	.11	2.30	2.23	10.85	5.44	2.52	.89	.00	.31	.00	25.45
1890-91	.13	2.16	.88	.58	1.27	3.02	.00	7.78	.06	.53	1.67	.00	18.08
1891-92	.00	.91	.93	T.	T.	1.67	3.24	3.30	1.75	.37	2.10	.08	14.35
1892-93	.00	.00	.00	.16	1.02	2.23	4.53	3.37	8.00	.48	.03	.00	19.82
1893-94	.20	.00	.05	1.05	.30	2.28	1.26	.88	1.15	.40	.56	.00	8.13
1894-95	.00	.16	.37	.15	.00	7.25	7.39	1.14	3.44	.64	.44	.00	20.98
1895-96	.00	.00	.00	.00	1.14	.66	2.02	.00	2.92	.37	1.00	.00	8.11
1896-97	T.	.17	.00	2.10	.98	1.09	3.40	5.40	3.41	.08	.11	.00	16.74
1897-98	T.	.00	.13	2.10	.21	.57	2.10	.60	.97	.48	1.08	.00	8.24
1898-99	.00	.00	.00	.03	.05	.44	2.03	.51	3.22	.07	.19	.95	7.49
1899-1900	.00	T.	.01	.81	1.47	.84	.92	.00	.92	1.96	1.71	.00	8.64
1900-1901	.34	.00	.23	.36	6.10	.00	3.48	4.58	.43	.56	1.23	.05	17.36
1901-2	.00	.27	.07	1.09	.28	.04	1.65	3.02	3.89	.57	.12	.15	11.15
1902-3	.01	.00	.00	.09	1.94	1.94	1.96	1.67	6.47	3.10	.24	.00	17.42
1903-4	.00	.15	.46	.07	.00	.00	.18	2.21	5.34	.80	.16	.00	9.37

Average, 34 seasons, 15.06.

In order to determine the relative weights of excessive development and deficiency in rainfall in bringing about this effect, rainfall tables are given and charts presented in which the excess and deficiency of rainfall for a period of years at Anaheim and at San Bernardino are shown (figs. 3 and 4).

Since the coastal plain basin is supplied chiefly by the drainage from Los Angeles, San Gabriel, and Santa Ana rivers, its water supplies are affected more by the rainfall within the San Gabriel and San Bernardino mountain ranges than by local rainfall. A composite

record, compiled from local records in each of these valleys and at various points within the coastal plain, would furnish the most satisfactory basis for comparison, but since excessive rainfall in one part

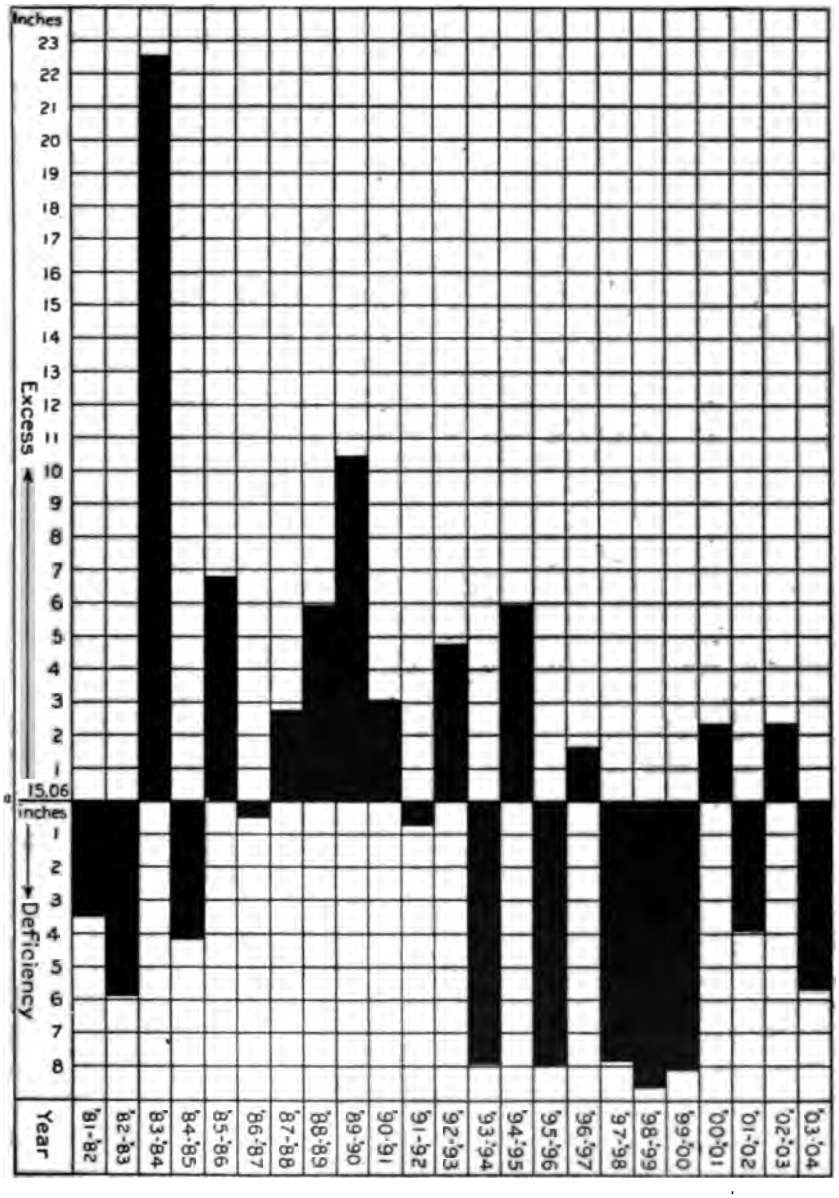

FIG. 3.—Chart showing departures from average rainfall at San Bernardino, Cal. a Average for 34 years (15.06 inches).

of southern California generally means excessive rainfall in other parts, although the absolute quantity at various points may differ greatly, the percentage of variation from the average at any point

may be assumed to be nearly equal to the percentage of variation from the average at other points.

By preparing charts, as those from San Bernardino and Anaheim are prepared, the departure from the average for each year is brought out instead of the total precipitation. It is thus seen at a glance whether the rainfall for any particular season is above or below the general average. Such charts are especially valuable for comparison with a profile like that of Mr. Neff's (fig. 2).

The underground waters should not be withdrawn faster than they

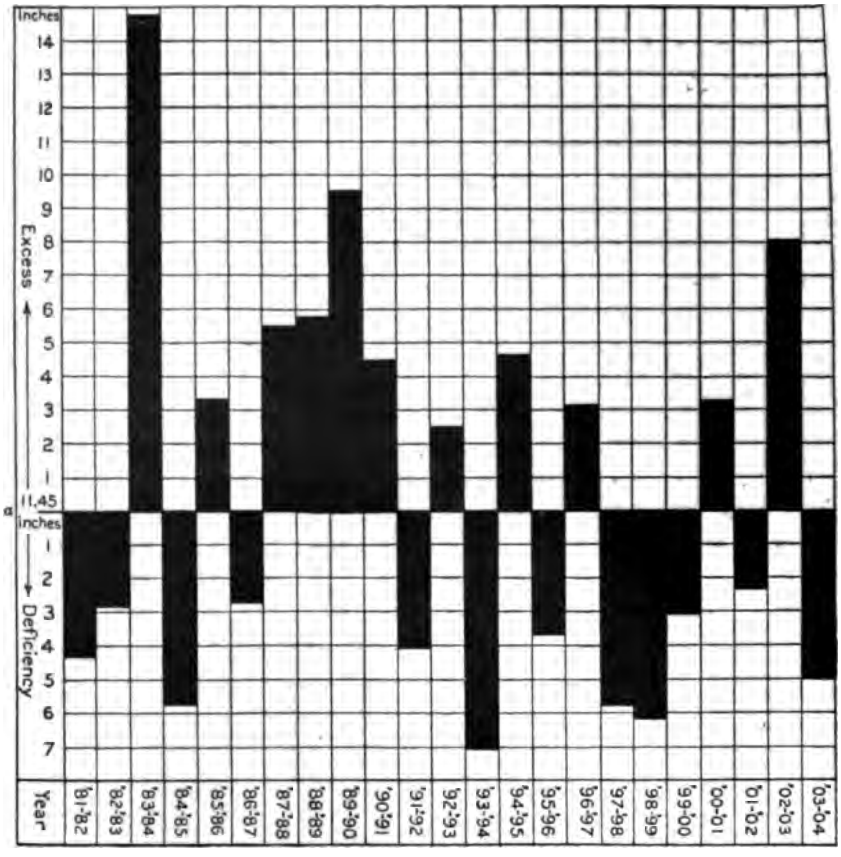

FIG. 4.—Chart showing departures from average rainfall at Anaheim, Cal. a Average for 26 years (11.45 inches).

are restored during years of average rainfall. In a conservative use of these stored waters, as regulating reservoirs and reserve supplies, they will of course be drawn down during years of deficiency in rainfall, but will recover during years of excessive precipitation. If the water plane continues to decline when the precipitation is above the average, and fails of restoration during years of great excess it means that a permanent lowering is taking place, whose rate may be expected to increase with further developments.

In the Neff wells the decline was sharpest, as should be expected, in the years of great deficiency which preceded 1901. The rainfall that winter, which was over 2 inches above the average in San Bernardino and somewhat more than 3 inches above the average at Anaheim, produced a temporary rise in the profile representing the Anaheim water level, but that rise was lost before the end of the succeeding August, proving that with the drafts at that time made upon the underground water bodies, a rainfall above the average was not sufficient to restore the waters annually taken out.

After this winter of excessive precipitation the decline was continuous, although not at a uniform rate, through the succeeding dry year, until early in 1903, when, in response to another year of increased rainfall, the water level rose about 1½ feet, but this effect had passed and the water level had fallen about to the level of the previous autumn, by August 1. The winter of 1903–4 was again a winter of marked deficiency and in the region about Anaheim there was a very rapid installation of pumps. In consequence, the water level declined during the spring of 1904 as rapidly as at any time since observations began, and on August 1, 1904, passed below the 50-foot level.

The significant point about these declines is that they have continued through years of more than average rainfall, although every foot of decline decreases pressure and yield of flowing wells and stops the flow of some wells entirely, thus tending to reduce the drafts. Evidently, the rapid increase in the number of wells more than offsets the decrease in individual yield, so that the constant effect is an increase in the total amount of water withdrawn. Eventually the falling water plane will cut off so many flowing and pumped wells that the drafts will no longer be in excess of the supply, and the water plane will then remain stationary. But that point will be permanently lower, and if drafts continue to be increased it may be much lower than the original ground-water level. Where it is finally fixed depends upon the water users themselves. One thing is certain, more water can not be continuously drawn from a reservoir of any sort than is supplied to it, and it is clear that more is now being taken from this portion of the coastal plain than is being added by natural processes. The water level therefore will continue to fall until by falling it has reduced the drafts until they are no longer in excess of supply. A series of years of heavy rainfall, which are earnestly hoped for by water users throughout southern California, would partly fill the depleted reservoirs, partly restore the original water level, brace the now tottering belief that the underground water resources are inexhaustible, and encourage further unwise development, so that when average conditions returned the decline would be more rapid than at present, and much harm would result. As a matter of fact,

the present cycle of dry years, coming thus early in the agricultural development of the region, will, if it continues long enough to call attention to the earnest need of conservation of subsurface supplies, be a scarcely disguised blessing. The general complaint, which one hears everywhere, of a scarcity of water means an awakening realization of the need of care, and is thus a most favorable omen. A public sentiment should be created which would make it impossible for any individual to use his water supplies carelessly, to leave artesian wells uncapped and flowing freely when the water is not needed, or to use upon his soil more than the necessary amount, and a further sentiment should be created unfavorable to the continued sinking of wells and installation of plants. This is much more difficult to create, because the bringing of more acreage under cultivation and the employment of capital and labor in such enterprises are regarded as general contributions to the prosperity and welfare of the section, and are welcomed accordingly. If, however, it is clearly understood that each additional plant thus installed is to a degree at the expense of those already in existence, since it contributes to the rapidity with which the water plane is lowering and to the expense, therefore, of lifting irrigation water, sentiment will change in this matter and it will be realized that it is better to protect the vested interests than to sacrifice these for a temporary increase in industrial activity.

In a region where underground water supplies are as important as here, and at the same time so liable to unwise overdevelopment, it may eventually be necessary to create a State commission with power to grant or to refuse to grant permits for drilling wells or installing pumping plants. Individual wishes and individual needs are scarcely to be trusted in matters which so vitally affect the community and the State at large. Especially is this true because it is just those landowners whose wells are most favorably located who, having an abundance of water themselves, do not realize the scarcity at other points, and drain away the water most rapidly from their less favorably situated neighbors.

INTERDEPENDENCE OF WELLS.

In general each well in the coastal plain, whether flowing or pumped, affects every other well in the same region. Widely separated wells will not have a measurable effect upon one another, the actual effect being too small for observation. All drain from a common source, the body of saturated sands and gravels which underlie the wide plain between the Puente Hills and the sea—and whatever reduces the amount of water in that body of alluvium affects all wells which draw from it.

The wells on the lowest ground are always most advantageously situated when the source of water is common to all, and there is no impervious obstruction to interfere with free circulation. These lower

wells affect the higher ones more than they are affected by them, the mutual effect thus differing in degree.

In the artesian area, where the water, in its slow movement toward the sea, has passed below strata of nearly impervious clay, strong flows may often be obtained from deeper horizons whose confining stratum extends farther inland and whose pressure therefore originates at a higher point, after shallow wells have ceased to flow. The yield from such a deeper well will usually be less than if it had been drilled before the shallow well failed, because its pressure has also been affected by the general lowering of the water plane; hence a degree of interdependence exists even between those water horizons which are separated by clay lenses.

This fact of interdependence may mean that users of underground waters in the coastal plain region are rivals; it should also mean that they have a common interest in preventing waste and conserving their supplies.

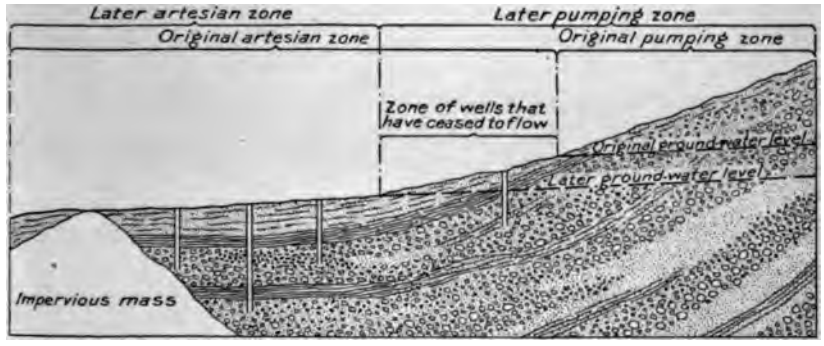

FIG. 5.—Diagrammatic cross section of southern California coastal plain.

COST OF WELLS.

As guides to the cost of wells the following tables of approximate charges for boring have been prepared from figures furnished by Messrs. Cunningham, Raines, Schantz, and Burrows, who have had much experience as well drillers in the Santa Ana region. The figures given by responsible drillers accord closely, the difference being due to local conditions or to the custom in one neighborhood of making an average estimate for a number of hundred feet, while in another this average may be split up into specific rates for integral parts of the total.

In the following table the price of drilling the first hundred feet and the additional price for each 50-foot increase in depth are given for the diameters generally used in this region:

Cost of drilling wells.

	4 inch.	5 inch.	6 inch.	7 inch.	8 inch.	9½ inch.	10 inch.
	Per ft.	*Per ft.*	*Per foot.*	*Per foot.*	*Per foot.*	*Per foot.*	*Per ft.*
First 100 feet	$0.30	$0.30	$0.35 to $0.40	$0.40	$0.40 to $0.50	$0.60 to $0.65	$0.65
Additional for each 50 foot increase	.25	.25	.20 to .30	.20 to .35	.20 to .35	.20 to .35	.35

For hydraulic wells the charge is 30 to 40 cents per foot, the diameter 2 to 4 inches and the depth usually less than 100 feet.

The Baker Iron Works, of Los Angeles, have furnished the following general price per foot for riveted steel casing made up into 2-foot joints of the sizes and gages generally used for wells. Such prices will vary with the steel market, so that constant minor departures from them are to be expected.

Cost of well casing.

Diameter.	Gage.	Price per foot.	Diameter.	Gage.	Price per foot.
Inches.			*Inches.*		
4	16	$0.32	9½	14	$0.75
4	14	.38	9½	12	.94
5	16	.35	10	16	.68
5	14	.43	10	14	.78
6	16	.42	10	12	.98
6	14	.50	12	14	.80
7	16	.48	12	12	1.10
7	14	.55	12	10	1.40
8	16	.55	14	12	1.30
8	14	.64	14	10	1.55
8	12	.78	16	12	1.55
9½	16	.65	16	10	1.70

For riveting starters the charges are from 20 to 25 cents per foot extra.

Rings range through about the following prices:

Cost of rings.

4 inch	$2.75
5 inch	3.50
6 inch	4.00
7 inch	5.00
8 inch	6.50
9 inch	7.00
10 inch	10.00
12 inch	12.00
14 inch	17.00
16 inch	20.00

In the artesian belt hydraulic wells of 2 or 3 inch diameter are often put down, and the standard pipes for these cost, respectively, 15 and 25 cents each per foot.

DESCRIPTION OF MAPS AND TABLES.

The maps presented with this report show (*a*) the areas irrigated in the spring of 1904, when the field work was done (Pls. II, III), (*b*) the pumping plants and distributing systems by which the water is secured and conducted to the land where it is used (Pls. II, III), (*c*) the areas of artesian water-bearing land at the beginning of 1904, and the original artesian area (Pls. VI, VII), (*d*) the zones of relative alkalinity in the underground waters (fig. 6), and (*e*) the elevation of the planes of saturation outside of the present artesian belt (Pls. VI, VII). Where the data are sufficient the elevation of the plane of saturation is shown by means of contours. The elevations used in determining the position of this plane are those furnished by the topographic sheets, which serve as bases for the maps. It is to be regretted that these elevations are somewhat inaccurate, as the sheets were prepared ten years ago, before modern refined topographic methods were in vogue; hence the hydrographic contours themselves are not exact as to absolute elevations. However, they are believed to show, with fair accuracy, the relation of the water level to the topographic contours as the latter are drawn. This is the essential thing, since it enables the user of the maps to tell the distance to the water plane by the difference between the elevations shown by the two sets of contours. Another matter for regret is that these contours have but an ephemeral value as practical guides in developing water. With the water plane lowering at a rate of from 0 to 5 feet per year, the depth to it, as recorded by these maps, will soon cease to be correct. But as records of the position of the water plane in the early part of the year 1904, they will always have interest and will serve as a basis for comparison in later years.

On the mesa lands, and in areas generally where the wells are few and the water plane is irregular, sufficient data do not exist to show its position by contour. In these cases the water elevations at the individual wells visited are shown in purple-blue figures, the positions of the wells in the same color, and the numbers of the wells in black.

From the determinations, by means of the electrolytic bridge, of the amounts of salts carried in solution in the waters, a map (fig. 6) has been prepared upon which waters with equal mineral contents are grouped in zones. The boundaries separating these zones are not sharp, but the grouping brings out the general fact that in the vicinity of the bed-rock hills of Tertiary shale and sandstone, which are impregnated with alkaline salts, the ground waters are distinctly more alkaline than at a greater distance, where they are derived chiefly from

the floods of the larger streams. The purer waters of the lowlands, too, make distinct bays in the less pure hill waters, and the position of these bays is so related to the surface channels of Santa Ana River and Santiago Creek as to suggest that they mark the position of the most rapid underground percolation from these streams, as sources, toward the artesian areas below.

On the maps showing the wells (Pls. VI, VII), those that were flowing at the time the field work was done are given a distinctive symbol as are those on which pumping plants are installed, when the water

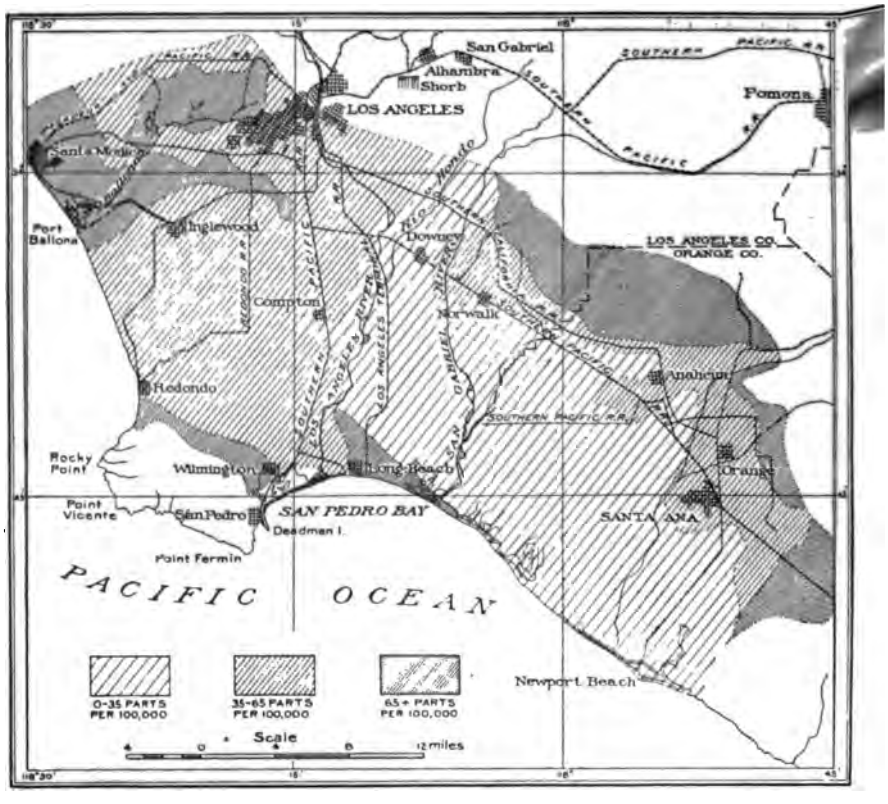

FIG. 6.—Map showing approximate amounts of dissolved solids in the underground waters of the eastern part of the coastal plain of southern California.

thus pumped is used in irrigation. The flowing wells will rapidly decrease for a time in number and yield, it is expected, and the pumping plants are increasing in number with equal rapidity.

Each well is numbered on the map, and in the tables the essential facts concerning it are given under the same number. Where it has been possible to secure definite data, the cost of the well and of the machinery is given.

Where wells were flowing or pumped and were accessible for measurement, the yield is given in the table; in other cases, where it was not possible to make independent determinations, statements of operators of pumping plants were taken.

The approximate proportion of salts in the water—that is, its alkalinity—was determined by the electrolytic bridge and the result appears in one of the columns. These results have also been generalized in the map (fig. 6) already referred to. In most cases they should be correct within three or four parts per 100,000; greater refinement is not possible with the rapid methods used. All the deep wells in the area furnish excellent potable waters, and of course they are thoroughly safe for irrigation. An occasional shallow well shows a much higher degree of alkalinity, due probably to a source too near the surface in alkaline soils. Near the coast, also, some wells are quite brackish, and generally the mesa waters, and those nearer the foothills, composed of alkali-bearing rocks, show the effects of their environment.

Under the heading "Map location," a letter and a number appear. The map has been divided into rectangles which are lettered horizontally and numbered vertically. This column tells at once in which of the rectangles the well is to be sought, and enables any number on the map to be readily found. The other columns in the table are self-explanatory.

ACKNOWLEDGMENTS.

The field work in the Anaheim quadrangle has been done almost entirely by Mr. A. J. Fisk, jr., Mr. E. R. Furstenfeld assisting for a short period.

Mr. A. P. McCarton has collected the greater part of the information embodied in the Santa Ana maps and tables, Mr. W. N. White being responsible for a small portion.

In securing information concerning the greater irrigating systems, the officers of the companies have been appealed to and have responded with unfailing courtesy. Mr. Mansur has supplied data as to the practice under the Santa Ana Valley system, and Mr. Sherwood, representing the Anaheim Union Water Company, has responded to inquiries about that system. Sketches of the Carpenter and Serrano companies, deriving their waters from Santiago Creek, have been furnished by Mr. Helwig and Mr. Collins.

Well drillers generally have answered queries as to phases of the work in which they are most interested, and Mr. E. C. Cunningham, of Santa Ana, in particular, has been reliable and obliging in these matters.

The office work involved in compiling the tables from the field records and in preparing the maps for publication, has been done largely by Mr. A. J. Fisk, jr.; assistance here has also been rendered by Mr. W. N. White.

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
51	Mrs. H. Bower	Santa Ana	G-16	1904	Dug, 7-foot diameter, 42 feet; bored, 10-inch, 150 feet.	127	85	192	55	....	Gas	$325.00	$1,150.00	Irrigation	59
52	Geo. Slocum	do	H, G-16	1886	Bored, 6-inch	134	90	60	70	63	Wind		+350.00	Domestic	
53	Mrs. N. Young	do	H, G-16	1884	Bored, 7-inch	137	93	60	42	61	do		+400.00	do	
54	C. C. L. Lesslie	do	G-16	1885	do	133	93	47	68	63	do			do	
55	E. Rurup	do	G-16		do	133	93	48	47	64	do			do	
56	M. E. Helme	do	H-17		do	138	96	44							
57	W. W. Halesworth	do	H-17	1885	do	136	97	55	54	....	Wind	75.00	+1,300.00	Domestic	
58	Geo. W. Ford	do	H-17	1889	do	132	77	125	40		do	150.00	+300.00	Domestic; stock	
59	Mrs. B. M. Edgers	do	H-17		do	136			48		do			Domestic	
60	Ransom Reid	do	H-17		Dug, 3 by 3 foot	135	81	70							
61	Mrs. A. W. Greenwald	do	H-17	1893	Bored, 7-inch	132	92	55	47		Wind	60.00	60.00	Domestic; stock	
62	E. D. Whittlesey	do	H-17		do	137	94	55	52	62	Hand			Domestic	
63	Mrs. M. E. Martin	do	H-17	?1878	do	138	93	55	70	61	Wind			Domestic; stock	
64	E. F. Greenleaf	do	H-17	1882	Bored, 6-inch	133	95	53	52	63	do			Domestic	
65	O. H. Greenwald	do	H-17	1902	Bored, 7-inch	132	92	60	46	62	Hand	60.00	10.00	do	
66	Sarah A. Ross	do	G-17	1882	do	129	95	78	80	63	do	80.00		do	
67	H. Diers	do	G-17	1900	do	127	100	52	39	62	Wind	60.00	+300.00	do	
68	E. A. Clardy	do	G-17	1903	do	123	97	48	95	63	Hand	*65.00		do	
69	F. L. Bundy	do	G 17	1900	do	119	90	123	39	65	Wind			do	
70	Wm. Keely	do	G-17		Bored, 5-inch	120			39		do			do	

71	C. J. Ross	do	G-17	1888	Bored, 7-inch	119	95	57	47	60	Hand			do		
72	G. D. Lillie	do	G-17		do	116			47		Wind			do		
73	Fred A. Marks	do	G-17	1880	do	110	90	55	35	60	do			Domestic; stock		
74	A. E. Hawley	do	G-17	1888	do	108	90	63	35	66	do			Domestic		
75	E. S. Nash	do	G-17	1888	do	103	82	87	50	65	do			do		
76	T. L. Scudder	do	G-17	1902	do	99	79	84	50	65	do	85.00	+150.00	Domestic; stock; irrigation.		
77	S. G. Cooper	do	G-17	1880	Bored, 10-inch	104	84	80	50	65	do			Domestic		
78	S. P. McNeal	do	G-17	1880	Bored, 7-inch	113	92	64	19	63	do	100.00	+400.00	do		
79	J. C. McCaul	do	G-17	1902	Bored (2), 7-inch	116					Gas		2,500.00	Irrigation		†110
80	do	do	G-17	?1888	Bored, 7-inch	111			55		Wind			Domestic; stock		
81	do	do	G-17		Bored, 10-inch	110			40	63	Hand			Stock		
82	W. G. Neville	do	G-17		Bored, 7-inch	117	98	94	52		Wind			Domestic		
83	Van Horn	do	G-17		do	108	96	23	51	62	Hand			do		
84	Peter Rassmusen	do	G-17	1903	do	108	96	65	44	65	do	135.00		do		
85	R. R. Raymond	do	G-17	?1882	Bored (2), 7-inch	127	107	45	60		Wind	100.00	+100.00	Domestic; stock		
86	do	do	G-17	?1882	Bored, 7-inch	123	103	175			Hand	200.00	15.00	Stock		
87	J. C. Kirby	do	G-17	?1882	do	130	110	45	51	64	do			Domestic		
88	L. A. Greenleaf	do	G-17	1897	do	132	111	119	42		Wind	80.00	+200.00	do		
89	J. Steward	do	G-16		do	120			38		do			do		
90	Right & Barcus	do	G-16		do	125	75	65	44		do			do		
91	J. A. Smiley	do	G-16	1902	do	136	94	56	49		do	55.00	30.00	do		
92	S. P. Co	do	G-16	1900	do	137	92	52	45	68	Hand			do		
93	M. Witt	do	H-16	1901	do	148	108	155	39		Wind	275.00		do		
94	T. L. Kling	do	G-15, 16	1892	do	127	93	43	22	67	do			Domestic; stock		
95	J. W. Berry	do	G-16		do	130	97	43	87	66	Hand			Domestic		
96	A. R. Kelsey	do	G-15	1898	do	136	92	48	42	68	Wind	25.00	+150.00	Domestic; irrigation.		
97	Fred Schlueter	do	G-15		Dug, 3 by 3 foot	127	98	42	56	63	Hand			Domestic; stock		
98	Mrs. Martha Shaffer	do	G-15	1884	do	137	99	40	42		Wind			Domestic		
99	W. T. Walton	do	G-15	1896	Dug, 4 by 4 foot	133	95	40	48	60	Hand			do		
100	T. B. Laidley	do	G-15	1902	Bored, 6-inch	133	91	60	56	62	do	*100.00		do		
101	Mrs. Martha Shaffer	San Juan Cajon	G-15	1902	Bored, 10-inch	127	82	88			Gas			Irrigation		
101a	do	do	G-15	1902	Bored, 9½-inch	127	82	330			do	*1,250.00		do		†114
101b	do	do	G-15	1902	Bored, 7-inch	127	82	200			do			do		

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
51	Mrs. H. Bower	Santa Ana	G-16	1904	Dug, 7-foot diameter, 42 feet; bored, 10-inch, 150 feet.	127	85	192	55	....	Gas	$325.00	$1,150.00	Irrigation	59
52	Geo. Slocum	do	H, G-16	1886	Bored, 6-inch	134	90	60	70	63	Wind		+350.00	Domestic	
53	Mrs. N. Young	do	H, G-16	1884	Bored, 7-inch	137	93	60	42	61	do		+400.00	do	
54	C. C. L. Lesslie	do	G-16	1885	do	133	93	47	68	63	do			do	
55	E. Rurup	do	G-16		do	133	93	48	47	64	do			do	
56	M. E. Helme	do	H-17		do	138	96	44							
57	W. W. Halesworth	do	H-17	1885	do	136	97	55	54	....	Wind	75.00	+1,300.00	Domestic	
58	Geo. W. Ford	do	H-17	1889	do	132	77	125	40	....	do	150.00	+300.00	Domestic; stock	
59	Mrs. B. M. Edgers	do	H-17		do	136			48	....	do			Domestic	
60	Ransom Reid	do	H-17		Dug, 3 by 3 foot	135	81	70							
61	Mrs. A. W. Greenwald	do	H-17	1893	Bored, 7-inch	132	92	55	47	....	Wind	60.00	60.00	Domestic; stock	
62	E. D. Whittlesey	do	H-17		do	137	94	55	52	62	Hand			Domestic	
63	Mrs. M. E. Martin	do	H-17	?1878	do	138	93	55	70	61	Wind			Domestic; stock	
64	E. F. Greenleaf	do	H-17	1882	Bored, 6-inch	133	95	53	52	63	do			Domestic	
65	O. H. Greenwald	do	H-17	1902	Bored, 7-inch	132	92	60	46	62	Hand	60.00	10.00	do	
66	Sarah A. Ross	do	G-17	1882	do	129	95	78	80	63	do	80.00		do	
67	H. Diers	do	G-17	1900	do	127	100	52	39	62	Wind	60.00	+300.00	do	
68	E. A. Clardy	do	G-17	1908	do	123	97	48	95	63	Hand	*65.00		do	
69	F. L. Bundy	do	G 17	1900	do	119	90	123	39	65	Wind			do	
70	Wm. Keely	do	G-17		Bored, 5-inch	120			39		do			do	

71	U. J. Ross	do	G-17	1880	Bored, 7-inch	119	89	37	47	66	Hand			do	
72	G. D. Lillie	do	G-17		do	116			47		Wind			do	
73	Fred A. Marks	do	G-17	1880	do	110	90	55	35	66	do			Domestic; stock	
74	A. E. Hawley	do	G-17	1888	do	108	90	63	35	66	do			Domestic	
75	E. S. Nash	do	G-17	1888	do	103	82	87	50	65	do			do	
76	T. L. Scudder	do	G-17	1902	do	99	79	84	30	65	do	85.00	+150.00	Domestic; stock; irrigation.	
77	S. G. Cooper	do	G-17	1880	Bored, 10-inch	104	84	80	50	65	do			Domestic	
78	S. P. McNeal	do	G-17	1880	Bored, 7-inch	13	92	64	19	63	do	100.00	+400.00	do	
79	J. C. McCaul	do	G-17	1902	Bored (2), 7-inch	116					Gas		2,500.00	Irrigation	†110
80	do	do	G-17	?1888	Bored, 7-inch	111			55		Wind			Domestic; stock	
81	do	do	G-17		Bored, 10-inch	110			40	63	Hand			Stock	
82	W. G. Neville	do	G-17		Bored, 7-inch	117	98	94	52		Wind			Domestic	
83	Van Horn	do	G-17		do	108	96	23	51	62	Hand			do	
84	Peter Rassmusen	do	G-17	1903	do	108	96	65	44	65	do	135.00		do	
85	R. R. Raymond	do	G-17	?1882	Bored (2), 7-inch	127	107	45	60		Wind	100.00	+100.00	Domestic; stock	
86	do	do	G-17	?1882	Bored, 7-inch	123	103	175			Hand	200.00	15.00	Stock	
87	J. C. Kirby	do	G-17	?1882	do	130	110	45	51	64	do			Domestic	
88	L. A. Greenleaf	do	G-17	1897	do	132	111	119	42		Wind	80.00	+200.00	do	
89	J. Steward	do	G-16		do	120			38		do			do	
90	Right & Barcus	do	G-16		do	125	75	65	44		do			do	
91	J. A. Smiley	do	G-16	1902	do	136	94	56	49		do	55.00	30.00	do	
92	S. P. Co	do	G-16	1900	do	137	92	52	45	68	Hand			do	
93	M. Witt	do	H-16	1901	do	148	108	155	39		Wind	275.00		do	
94	T. L. Kling	do	G-15, 16	1892	do	127	93	43	22	67	do			Domestic; stock	
95	J. W. Berry	do	G-16		do	130	97	43	87	66	Hand			Domestic	
96	A. R. Kelsey	do	G-15	1898	do	136	92	48	42	68	Wind	25.00	+150.00	Domestic; irrigation.	
97	Fred Schlueter	do	G-15		Dug, 3 by 3 foot	127	98	42	56	63	Hand			Domestic; stock	
98	Mrs. Martha Shaffer	do	G-15	1884	do	137	99	40	42		Wind			Domestic	
99	W. T. Walton	do	G-15	1896	Dug, 4 by 4 foot	133	95	40	48	60	Hand			do	
100	T. B. Laidley	do	G-15	1902	Bored, 6-inch	133	91	60	56	62	do	*100.00		do	
101	Mrs. Martha Shaffer	San Juan Cajon	G-15	1902	Bored, 10-inch	127	82	88			Gas			Irrigation	
101a	do	do	G-15	1902	Bored, 9½-inch	127	82	330			do	*1,250.00		do	†114
101b	do	do	G-15	1902	Bored, 7-inch	127	82	200			do			do	

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
102	Mrs. Martha Shaffer..	San Juan Cajon ..	G-15		Bored, 7-inch....	127	.....	70	.....	.....	Wind	.....	.....	Stock	.....
103	M. C. Cuddeback.....	Santa Ana.....	G-15	1898	Dug, 3 by 3 foot..	133	91	43	49	.....	.....do	.....	.....	Domestic	.....
104	Otto Hoffman	.....do	G-15	.....	.....do	130	88	44	47	61	Hand.....	.....	.....	.....do	.....
105	Thos. H. Brown	.....do	G-15	1903	.....do	144	.....	44	.....	.....	.....do	.....	.....	.....do	.....
106	.....do	.....do	G-15	.....	.....do	148	101	48	47	64	.....do	.....	.....	.....do	.....
107	J. L. Sanborn.....	.....do	H-15.....	.....	Bored, 7-inch....	149	.....	80	44	62	.....do	.....	.....	.....do	.....
108	.....do	.....do	H-14, 15.	1885	.....do	152	102	80	47	62	Wind.....	.....	.....	.....do	.....
109	John C. Keefe.....	.....do	H-14.....	.....	.....do	154	101	54	53	....	.....do	.....	.....	Domestic; stock .	.....
110	R. A. Adams	.....do	H-14....	1898	Dug, 3 by 3 foot .	157	107	60	49	64	Hand.....	.....	.....	Domestic	.....
111	.....do	.....do	H-14....	1900	Bored, 7-inch....	163	108	105	29	....	Wind.....	$150.00	+$300.00	.....do	.....
112	John Bendick	.....do	H-15....	1883	Bored, 8-inch....	161	105	59	35	66	Hand.....	150.00	50.00	.....do	.....
113	G. Enechel	.....do	H-15.....	.....	Dug, 2½-foot diameter.	159	100	85	41	....	Wind.....	.....	.....	.....do	.....
114	Geo. Dierker	.....do	H-15....	1897	Bored, 7-inch....	158	.....	70	34	67	Hand.....	.....	.....	.....do	.....
115	John A. Irvine	.....do	H-15.....	.....	.....do	168	92	79	37	62	Wind	.....	.....	.....do	.....
116	J. D. Parker.....	.....do	H-15....	1874	.....do	155	96	75	38	.....	.....do	.....	.....	.....do	.....
117	J. V. Green.....	.....do	H-15.....	.....	.....do	160	97	78	37	69	Hand.....	.....	.....	.....do	.....
118	Mrs. E. Dreyer	.....do	H-15....	1898	.....do	162	95	90	....	....	Wind.....	.....	.....	.....do	.....
119	E. Meehan	.....do	H-15....	1897	.....do	168	123	88	39	67	.....do	.....	.....	.....do	.....
120	W. H. Burnham.....	.....do	H-15....	1894	.....do	172	112	126	38	61	.....do	100.00	60.00	.....do	.....
121	.....do	.....do	H-15....	1899	Bored, 10-inch...	173	113	124	38	61	.....do	125.00	75.00	Domestic; irrigation.	.....
122	.....do	.....do	H-15....	1893	Bored, 7-inch....	173	113	122	38	61	Gas.....	100.00	450.00	.....do	.....

123	Mrs. Martha Ronty	do	I-17	1882	do	148	74	104	39	58	Hand			Domestic		
124	Thos. Morris	do	I-17	1884	do	170	108	90	39		Wind			do		
125	J. A Booty	do	I-17		do	170	96	150	39		do			do		
126	A. E. Marshall	do	I-17	1901	Dug, 3 by 3-foot	185		85	53	61	Hand			do		
127	A. Deventier	do	I-17	1894	Bored, 7-inch	170	107	93	49	63	Wind	175.00		do		
128	F. S. Buchheim	do	I-17	1894	do	169	97	80	53	61	do			do		
129	K. Claaver	do	I-17	1903	do	167	107	140	36	64	Hand	235.00	22.00	do		
130	R. H. English	do	F-17		Bored, 10-inch	82	62	50	35		Wind			Domestic; stock		
131	do	do	F-17	1903	do	77	57	187								
132	G. A. Clark	Las Bolsas	F-17	1901	Driven, 2-inch	75	57	40	52	62	Hand			Domestic		
133	A. N. Van Nest	do	F-17	1897	Driven, 1¼-inch	78	72	14	78	62	do			do		
134	J. H. Young	Santa Ana	F-17	1904	Dug, 4 by 4-foot	83	63	23		62	do			do		
135	Ben Clarke	do	F-17	1903	Driven, 1¼-inch	76	66	19	36	64	do		7.50	do		
136	W. E. Ward	Las Bolsas	F-16,17		Bored, 7-inch	101	80	90	35		Wind			do		
137	L. F. Marsile	do	F-16	1880	Bored, 4-inch	103	81	140	91	68	Hand			do		
138	do	do	F-16	1902	Bored, 10-inch	104	81	94	26		Gas		1,650.00	Irrigation		†80
138a	do	do	F-16	1903	Bored, 7-inch	104	81	94	26		do					
139	J. H. Belt	do	F-16	1888	Bored, 4-inch	105	85	87	34		Wind			Stock		
140	do	do	F-16,17	1899	Bored, 7-inch	101	81	136	32	62						
141	B. F. Wolfe	do	F-16	1903	do	100	80	93	34	62	Hand	100.00	15.00	Domestic		
142	M. Atgen	do	F-17	1890	do	77	67	80	29		Wind			Domestic; irrigation.		
143	do	do	F-17	1901	Driven, 2-inch	77	71	17	78	62	Hand			Stock		
144	John Cudderback	do	F-17	1902	Bored (2), 7-inch	79	66	110			Gas		800.00	Irrigation		†60
145	Mrs. Clapp	do	F-17	1889	Bored, 7-inch	83	71	100	27		Wind			Domestic		
146	do	do	F-17	1898	Driven, 2-inch	80	72	14	78	62	Hand			Stock		
147	J. E. Brown	do	E-17	1892	Bored, 7-inch	77	65	157	35	63	Wind		+125.00	Domestic; irrigation.		
148	R. E. Beswick	do	E-17	1903	Driven, 1¼-inch	73	60	22	40	63	Hand			Domestic		
149	D. D. Armes	do	E-17	1888	Bored, 4-inch	70	54	147	33		Gas			Domestic; irrigation.		
150	J. Killefer	do	E-17	1902	Driven, 2-inch	70	62	110	29	65	Hand	*54.00		Domestic		
151	Otto Buell	do	E-17		Bored, 7-inch	69		150	43		Wind			Domestic; irrigation.		
152	E. D. Music	do	E-17		do	70	56	125	33	64	Hand			Domestic; stock		
153	Wm. Shearer	do	E-17		Bored, 4-inch	68	59	160	29		Wind			Domestic		

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°F.					*Miner's inches.*
205	T. H. Bowen	Las Bolsas	E-17	1899	Bored, 7-inch	77	61	118	28	64	Gas	$120.00	$700.00	Irrigation	†30
206	H. J. Foot	do	E-17	1882	do	77	61	133	33	65	Wind			Domestic; irrigation.	
207	H. W. Head	do	E-17	1876	do	73	59	215	32		do			Domestic	
208	H. Clinton	do	F-17		do	90	72	93	32	65	do			do	
209	Lucinda Reed	do	E-17	1892	Bored, 4-inch	85	71	142	31	63	do	125.00	45.00	do	
210	D. W. McDonald	do	F-16	1904	Bored, 10-inch	108	88	80	36	63	Gas	*700.00		Irrigation	†35
211	A. B. Everts	do	F-17	1882	Bored, 7-inch	108	88	115	35	63	Wind			Domestic	
212	R. L. Greenleaf	do	F-17	1903	do	117	97	110	31	64	Hand			do	
213	D. E. Cozad	do	F-17	1897	Bored, 4-inch	119	99	77	37	63	do			do	
214	J. R. Hill	do	F-17	1902	Bored, 7-inch	122	99	92	35	64	Gas			Irrigation	†30
215	J. J. Swartzbuch	do	F-17	1892	do	124	97	98	29		Wind	100.00		Domestic	
216	Hending & Nichols	do	F-15	1902	Bored, 10-inch	120	80	120			Gas	*1,000.00		Irrigation	†46
217	J. O. Nichols	do	F-15	1903	Bored, 4-inch	118	80	131	32		Wind			Domestic	
218	do	do	F-15	1899	Bored, 7-inch	118	80	109			do			Irrigation	
219	N. Jacobson	Santa Ana	G-15		do	125		62	36	64	Hand			Domestic	
220	C. O. Ford	San Juan Cajon	G-14, 15	1897	Bored, 7-inch (2); bored, 9½-inch.	140	89	70	34		Gas	200.00	1,260.00	Irrigation	†77
221	do	do	G-14, 15	1903	Bored, 9½-inch	140	89	92	34						
222	do	do	G-15	1895	Bored, 4-inch	140	89	72	36	62	Wind			Domestic	
223	J. T. Megeath	Las Bolsas	F-16	1898	Bored, 7-inch	110	86	100	34		do	100.00	†100 00	Domestic; irrigation.	
224	Peter Brady	do	F-16		Driven, 1¼-inch	108	92	16	64	65	Hand			Domestic	

176	F. H. Teel	do	D-17	1890	Bored, 4-inch	65	52	158	29	65	Wind			Domestic; irrigation.	
177	Mrs. W. H. Morgan	do	D-17	1896	do	62		145	31	65	Hand			Domestic	
178	H. W. Davis	do	C-17	1882	Bored, 7-inch	51	51	90	28	64	do			do	
179	do	do	C-17	1882	do	52	51	150	28	62	Gas		550.00	Irrigation	
180	W. N. H. Evans	do	C-17		do	62	58	90	31	64	Hand			Domestic	
181	do	do	C-17		do	60	58	150	31	64	do			Stock	
182	J. S. McKee	do	C-17		do	61	54	129	29	63	do			Domestic	
183	J. H. Carlyle	do	C-17		do	64	56	210			Wind			Not used	
184	do	do	C-17	1882	do	64	56	140	25	63	do			Domestic	
185	J. P. Weinechank	do	B-17		do	52	48		31	64	do			Domestic; irrigation.	
186	S. R. Holdeman	do	C-17	1882	do	58	55	152			Gas		675.00	Irrigation	†50
187	do	do	C-17	1889	do	55	53	154	31	64	Hand			Domestic	
188	A. O. Thompson	do	B-17	1882	do	49	49	103	30	64	Artesian			Stock	
189	J. C. Thompson	do	B-17	1882	do	47	47	65	25	63	do			Domestic	
190	R. R. Overlander	do	B-17		do	49	49	123	27	62	Gas		400.00	Irrigation	
191	J. Magenty	do	B-17	1898	do	49	49	147	27	62				Not used	
192	do	do	B-17	1890	Bored, 4-inch	49	49	148	28	62	Hand			Domestic	
193	D. M. Watts	do	B-17	1878	Bored, 8-inch	48	48	90	26	64	Wind			Stock; irrigation.	
194	Lee Mahan	do	B-17		Bored, 4-inch	48	48	103	27	64	Hand			Domestic	
195	J. L. Carpenter	do	B-17	1892	Bored, 7-inch	51	49	155	29	65	Wind			do	
196	R. E. Blakey	do	B-17		do	48	48	121	27	64	Artesian			Not used	3
197	do	do	B-17		do	48	48	118	27	64	do			Domestic	1
198	W. A. Parmel	do	C-17	1897	do	65	54	156	26	63	Wind			do	
199	L. W. Jones	do	D-17		do	73	63	100	29		Gas		400.00	Domestic; irrigation.	
200	Wm. Adams	do	D-17	1897	Bored, 4-inch	76	57	101	31	64	Wind			do	
201	M. A. Yetter	do	D-17		do	74			31	62	do			Domestic	
202	A. McAlhanny	do	D-17	1882	Bored, 7-inch	75			31	65	Hand			do	
203	R. T. Barnes	do	D-17	1904	do	85	73	114	37		Wind	105.00	40.00	do	
204	J. G. Dunn	do	E-17	1885	do	81	67	134	31	64	do			Domestic; irrigation.	

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°F.					*Miner's inches.*
205	T. H. Bowen	Las Bolsas	E-17	1899	Bored, 7-inch	77	61	118	28	64	Gas	$120.00	$700.00	Irrigation	†30
206	H. J. Foot	do	E-17	1882	do	77	61	133	33	65	Wind			Domestic; irrigation.	
207	H. W. Head	do	E-17	1876	do	73	59	215	32		do			Domestic	
208	H. Clinton	do	F-17		do	90	72	93	32	65	do			do	
209	Lucinda Reed	do	E-17	1892	Bored, 4-inch	85	71	142	31	63	do	125.00	45.00	do	
210	D. W. McDonald	do	F-16	1904	Bored, 10-inch	108	88	80	36	63	Gas	*700.00		Irrigation	†35
211	A. B. Everts	do	F-17	1882	Bored, 7-inch	108	88	115	35	63	Wind			Domestic	
212	R. L. Greenleaf	do	F-17	1903	do	117	97	110	31	64	Hand			do	
213	D. E. Cozad	do	F-17	1897	Bored, 4-inch	119	99	77	37	63	do			do	
214	J. R. Hill	do	F-17	1902	Bored, 7-inch	122	99	92	35	64	Gas			Irrigation	†30
215	J. J. Swartzbuch	do	F-17	1892	do	124	97	98	29		Wind	100.00		Domestic	
216	Hending & Nichols	do	F-15	1902	Bored, 10-inch	120	80	120			Gas	*1,000.00		Irrigation	†46
217	J. O. Nichols	do	F-15	1903	Bored, 4-inch	118	80	131	32		Wind			Domestic	
218	do	do	F-15	1899	Bored, 7-inch	118	80	109			do			Irrigation	
219	N. Jacobson	Santa Ana	G-15		do	125		62	36	64	Hand			Domestic	
220	C. O. Ford	San Juan Cajon	G-14, 15	1897	Bored, 7-inch (2); bored, 9¼-inch.	140	89	70	34		Gas	200.00	1,260.00	Irrigation	†77
221	do	do	G-14, 15	1903	Bored, 9¼-inch	140	89	92	34						
222	do	do	G-15	1895	Bored, 4-inch	140	89	72	36	62	Wind			Domestic	
223	J. T. Megeath	Las Bolsas	F-16	1898	Bored, 7-inch	110	86	100	34		do	100.00	†100 00	Domestic; irrigation.	
224	Peter Brady	do	F-16		Driven, 1¼-inch	108	92	16	61	65	Hand				

276	Thos. Tonkley	do	D-16		Bored, 7-inch	85	75	120	29	62	do			do				
277	Maude Maddux	do	D-16		do	85		124	29	61	do			do				
278	James Hery	do	D-16		do	90	75	174	27	64	do			do				
279	A. B. Case	do	D-16	1903	do	85	71	146			Gas			Irrigation	† 30			
280	C. E. Sweetser	do	D-16	1892	do	87	71	102	30	61	Hand			Domestic				
281	Mrs. L. A. Simpson	do	D-16	1882	do	85	68	152			Gas		550.00	Irrigation	† 45			
282	S. M. Strong	Los Alamitos	B-16		do	67	61	150			Hand			Domestic				
283	E. Schneider	Las Bolsas	B-17	1899	do	60	56	145	28	63	Wind	145.00	75.00	do				
284	do	do	B-17		do	55	55	138	28	63	Artesian			Irrigation; stock				
285	M. A. Hausler	Los Alamitos	B-16	1878	do	66	63		31		Wind			Domestic				
286	Franklin Martin	Las Bolsas	B-16	1878	do	65	61	112	30	63	Hand			do				
287	do	Los Alamitos	B-16		do	60	60	178	29	64	Artesian			Stock				
288	Mrs. G. Treefathern	Las Bolsas	A-16		do	52	52	148	31	63	do			Domestic				
289	do	do	A-16		do	52	52				do			Stock				
290	A. J. Chaffee	do	D-16	1888	do	93	80	124	27	60	Hand			Domestic				
291	Garden Grove school district.	do	D-16	1877	do	95	81	122	28	63	Wind			do				
292	do	do	D-16	1903	Bored, 4-inch	95	81	117	28	63	Hand	140.00		Not used				
293	East side school district.	do	E-16	1900	Bored, 7-inch	103	85	120	29	64	do	140.00		Domestic				
294	J. Fulsom	do	D-16	1894	do	85	73	122	29	63	do	145.00		do				
295	Mrs. Edith Southern	do	C-16	1898	Hydraulic, 2-inch	80		117	28	63	Wind			do				
296	G. W. Crumley	do	C-16		Bored, 4-inch	80		104	28	63	Hand			do				
297	Mrs. M. Togg	do	C-16		do	80	62	134	28	63	do			do				
298	J. Winters	do	C-16	1903	Bored, 7-inch	80	70	146	28	63	Gas	145.00	400.00	Irrigation	† 25			
299	J. K. Edgerly	do	C-16		Bored, 4-inch	82	68	120	28	63	Hand			Domestic				
300	J. L. Holly	do	C-16	1888	Bored, 7-inch	81	74	120	28	63	do			do				
301	H. S. Atkinson	do	C-16		do	80	70	108	27		Wind			Domestic; irrigation.				
302	Mrs. A. Alger	do	C-16		do	75			28	63	Hand			Domestic				
303	T. J. Pulley	do	C-16		do	76			28		do			do				
304	Wm. Mitchell	do	B-16		do	61			28		Wind			do				
305	do	do	B-16		do	55	51	158	28	63	Hand			do				
306	Mrs. C. J. Harris	do	B-16	1898	Hydraulic, 2-inch	53	51	148	28	64	Wind	70.00	65.00	do				
307	Mrs. J. Jones	do	B-17		Bored, 7-inch	53	51	147	27	64	do			Domestic				
308	do	do	B-17		do	53	51	152	28	64	do			Stock				

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°F.					*Miner's inches.*
255	A. F. Mills	Las Bolsas	D-17	1880	Bored, 7-inch	78	66	105	19	61	Hand			Domestic	
256	do	do	D-17	1887	do	75	67	140			Gas		$750.00	Irrigation	†70
257	do	do	D-17	1897	do	72	67	150			do			do	
258	B. E. Stone	do	D-16		do	82		112	32	62	Hand			Domestic	
259	Mrs. Mary Faacks	Santa Ana	I-16	1903	do	187	126	137	38	62	do	$150.00		do	
260	Santa Ana Cemetery Co.	do	I-17		do	185		135	41		Gas			Irrigation	
261	C. B. Pulver	do	J-17	1900	do	175	91	184	38	61	Wind	250.00	125.00	Domestic	
262	H. Hockemeyer	do	J-16		do	178	95	143	34	63	Hand			do	
263	E. C. H. Franzen	do	J-16	1895	do	187	117	133	35		Wind	250.00	100.00	do	
264	C. Lehman	do	J-16	1901	do	187	87	170	41	62	do			do	
265	P. L. Buchheim	do	J-16	1891	do	195		103	39	62	do			do	
266	Pondorf estate	do	J-17		do	174		125	40	62	Hand			do	
267	Chas. Mueller	do	J-17	1890	do	165	113	100	46		Wind	*+1,500 00		do	
268	A. A. Sloan	do	J-17	1897	do	165	69	102	46	65	do			do	
269	F. G. Fuller	do	J-17	1888	do	155	86	80	49		do			do	
270	M. T. Fall	do	J-17	1902	Dug, 3-foot diameter.	158	89	72	42	64	Hand			do	
271	W. D. Coberly	do	J-17		Bored, 7-inch	154	104	90	35		Gas		275.00	do	
272	V. E. Blodgett	do	J-17	1882	Bored, 6-inch	157	102	65	40	63	Hand			do	
273	A. N. Cox	do	J-17	1900	Bored, 7-inch	165	93	100	46		Gas			do	
274	A. F. Marsile	do	I-17	1882	do	165		96	39		Wind			do	
275	F. Launders	Las Bolsas	D-16		Bored, 4-inch	82			30	61	Hand			do	

276	Thos. Tonkley	do	D-16		Bored, 7-inch	85	75	120	29	62	do					do		
277	Maude Maddux	do	D-16		do	85		124	29	61	do					do		
278	James Hery	do	D-16		do	90	75	174	27	64	do					do		
279	A. B. Case	do	D-16	1903	do	85	71	146			Gas					Irrigation		†30
280	C. E. Sweetser	do	D-16	1892	do	87	71	102	30	61	Hand					Domestic		
281	Mrs. L. A. Simpson	do	D-16	1882	do	85	68	152			Gas			550.00		Irrigation		†45
282	S. M. Strong	Los Alamitos	B-16		do	67	61	150			Hand					Domestic		
283	E. Schneider	Las Bolsas	B-17	1899	do	60	56	145	28	63	Wind		145.00	75.00		do		
284	do	do	B-17		do	55	55	138	28	63	Artesian					Irrigation; stock		
285	M. A. Hausler	Los Alamitos	B-16	1878	do	66	63		31		Wind					Domestic		
286	Franklin Martin	Las Bolsas	B-16	1878	do	65	61	112	30	63	Hand					do		
287	do	Los Alamitos	B-16		do	60	60	178	29	64	Artesian					Stock		
288	Mrs. G. Treefathern	Las Bolsas	A-16		do	52	52	148	31	63	do					Domestic		
289	do	do	A-16		do	52	52				do					Stock		
290	A. J. Chaffee	do	D-16	1888	do	93	80	124	27	60	Hand					Domestic		
291	Garden Grove school district.	do	D-16	1877	do	95	81	122	28	63	Wind					do		
292	do	do	D-16	1903	Bored, 4-inch	95	81	117	28	63	Hand		140.00			Not used		
293	East side school district.	do	E-16	1900	Bored, 7-inch	103	85	120	29	64	do		140.00			Domestic		
294	J. Fulsom	do	D-16	1894	do	85	73	122	29	63	do		145.00			do		
295	Mrs. Edith Southern	do	C-16	1898	Hydraulic, 2-inch	80		117	28	63	Wind					do		
296	G. W. Crumley	do	C-16		Bored, 4-inch	80		104	28	63	Hand					do		
297	Mrs. M. Togg	do	C-16		do	80	62	134	28	63	do					do		
298	J. Winters	do	C-16	1903	Bored, 7-inch	80	70	146	28	63	Gas		145.00	400.00		Irrigation		†25
299	J. K. Edgerly	do	C-16		Bored, 4-inch	82	68	120	28	63	Hand					Domestic		
300	J. L. Holly	do	C-16	1888	Bored, 7-inch	81	74	120	28	63	do					do		
301	H. S. Atkinson	do	C-16		do	80	70	108	27		Wind					Domestic; irrigation.		
302	Mrs. A. Alger	do	C-16		do	75			28	63	Hand					Domestic		
303	T. J. Pulley	do	C-16		do	76			28		do					do		
304	Wm. Mitchell	do	B-16		do	61			28		Wind					do		
305	do	do	B-16		do	55	51	158	28	63	Hand					do		
306	Mrs. C. J. Harris	do	B-16	1898	Hydraulic, 2-inch	53	51	148	28	64	Wind		70.00	65.00		do		
307	Mrs. J. Jones	do	B-17		Bored, 7-inch	53	51	147	27	64	do					Domestic		
308	do	do	B-17		do	53	51	152	28	64	do					Stock		

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
309	J. Beckwith	Las Bolsas	B-17	1884	Bored, 7-inch	54	51	144	28	64	Hand			Domestic	
310	J. Y. Anderson	do	A-17	1875	do	50	50	80	31	64	Artesian			Stock	
311	do	do	A-17	1879	do	48	48	120	31	64	Hand			Domestic	
312	do	do	A-17		do	48	48	147	31	64	do			do	4
313	Mrs. N. T. Lyman	do	A-16	1882	do	50	50	150	31	64	do			Irrigation	12
314	S. M. Alexander	do	A-16		do	48	48	190	30	64	do			Domestic	9
315	do	do	A-16		Bored, 3-inch	49	49		31	64	do			Irrigation	3
316	B. Phelps	do	A-16, 17		Bored, 7-inch	47	47	195	25	64	do			Domestic	
317	J. H. Cole	do	A-17		Bored, 4-inch	47	47	198	28	64	do			do	
318	W. O. Huston	do	A-17		Bored, 7-inch	47	47		23	61	do			do	
319	T. H. Thompson	do	E-16	1890	do	100	83	102	28	63	Gas	$105.00	$217.00	Domestic; irrigation.	
320	H. H. Vogt	do	A-17	1897	Hydraulic, 2-inch	47	47	127	31	64	Artesian	42.00		Domestic	1
321	do	do	A-17		Bored, 7-inch	49	49	157	31	64	do	138.00		Stock	4
322	do	do	A-17	1882	do	48	48	80			do			do	
323	do	do	A-17		do	49	49	80			do			do	
324	Jacob Walton	do	A-16	1882	do	49	49	240	29	64	Hand			Domestic	
325	H. H. Vogt	do	A-17		Hydraulic, 2-inch	46	46		33	64	Artesian			Irrigation	4
326	do	do	A-17		Bored, 7-inch	46	46		28	64	do			Stock	
327	do	do	A-17		Bored, 3-inch	46	46				do			Irrigation	12
328	W. H. Johnson	do	D-16	1892	Bored, 7-inch	92	76	162	31	64	Gas		900.00	do	†60
329	G. H. Lee	do	A-16	1882	Bored, 4-inch	49	49	96	23	65	Hand			Domestic	
330	do	do	A-16		Hydraulic, 2-inch	49	49	96	27	67	do			Stock	1

331	P. A. Raab	do	A-17	1890	Bored, 7-inch	49	49	166	23	66	Steam, artesian	200.00		Domestic		1
332	J. McCoy	do	A-17		do	44	44	205	31	65	Artesian			Domestic; stock		6
333	do	do	A-17		Hydraulic, 3-inch	40	40	100			do			Irrigation		
334	do	do	A-17		do	40	40	100	28	64	do			do		2
335	do	do	A-17	1879	Bored, 7-inch	45	45	236	28	64	do			do		
336	Westminster district school.	do	A-17		do	40	40		28	64	do			Domestic		
337	E. C. Phelps	do	A-17	1874	do	48	48	124			do			do		
338	J. N. Smith	Santa Ana	I-17	1892	do	145	94	63	38	61	Wind			do		
339	J. B. Gowdy	do	I-17	1900	do	142	92	135	38	63	do			Domestic; irrigation.		
340	McHenry Morrison	do	I-17	1901	do	155	94	101	38	60	do			Domestic		
341	J. A. Dowell	do	I-17	1901	Bored, 6-inch	150	94	127	38	60	do	172.50	+325.00	do		
342	A. S. Davis	do	J-17	1900	Bored, 7-inch	152	93	71	30	64	do	80.00	+100.00	Domestic; irrigation.		
343	A. F. Bennett	do	J-17	1901	do	148	106	100	39	62	do			Domestic		
344	F. Wakeham	do	J-17	1887	do	156	94	150	34	62	Gas, wind	*325.00		do		
345	E. R. Green	do	J-17	1900	do	146		90	40	60	Wind			do		
346	M. R. Blackmore	do	J-17		do	155	95	65	35	66	do			do		
347	T. H. Smith	do	J-17		Dug, 3 by 3 foot	147	96	54	47	64	Wind, gas			Domestic; stock		
348	C. W. Burns	do	J-17		Bored, 7-inch	145			41		Wind			Domestic		
349	W. B. Wall	do	J-17	1884	do	148		99	43	54	Gas			do		
350	H. L. Van Hise	do	K-17	1882	do	155		90	38	55	Wind			do		
351	C. E. Torrey	do	K-17	1901	do	160	90	88	37	52	do			do		
352	L. F. Thurston	do	K-17		do	152		90	37	56	do			do		
353	C. L. Cherel	do	K-17	1899	do	149		74	37	62	Hand			do		
354	H. H. Sparfield	do	K-17		do	149	70	99	42	61	do			do		
355	W. H. Kenyon	do	K-17		do	149		96	43	60	Wind			do		
356	Emily R. Smith	do	K-17	1892	do	149	100	65	37		do			Domestic; irrigation.		
357	A. G. Finley	do	L-17	1900	Dug, 3 by 3 foot	248	148	100						Not used		
358	J. D. Upton	do	K-16		Bored, 7-inch	196			42		Wind			Domestic		
359	Geo. Nay	do	K-17		do	170	93	77						Not used		
360	D. C. Drake	do	K-17	1894	Bored, 6-inch	196		75	40		Wind			Domestic		
361	W. D. Coberly	do	J-17	1882	Bored, 7-inch	165	92	85	41		do			do		
362	J. E. Luther	do	J-17	1899	do	168	92	112	46	65	do	105.00		do		

Wells in the Anaheim quadrangle—Continued.

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						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
363	A. E. Bradley	Santa Ana	J-17		Bored, 7-inch	178	95	94	47		Wind			Domestic	
364	E. J. Stellberg	do	J-15	1899	do	180		114	45	65	do			do	
365	Joe Fitchen	do	J-16	1892	do	220	117	127	38		do	$200.00		do	
366	Claus Seba	do	J-16		do	212	107	108	41		do			do	
367	R. Frick	do	J-16	1898	do	210	99	125	41		do			do	
368	C. B. Campbell	do	I-16		do	110			41		do			do	
369	J. A. Meeg	do	I-16	1899	do	205	116	134	38		do	200.00	$100.00	do	
370	A. D. Bishop	do	I-16	1880	do	205	121	109	50		Gas			do	
371	Joseph Young	do	I-16	1874	do	201	111	100	63		Wind, gas			do	
372	Mrs. H. Laeter	Las Bolsas	A-17		do	48	48	129	30	64	Artesian			Stock; irrigation	†4
373	do	do	A-17		Hydraulic, 3-inch	47	47	120	31	64	do			Domestic	
374	do	do	A-17	1874	Bored, 7-inch	47	47	122	31	64	Wind, artesian			do	
375	do	do	A-17		Driven, 4 by 6 inch.	48	48	65	26	64	Artesian				
376	H. Laeter	do	B-17		Bored, 4-inch	48	48	130	27	64	do			Domestic	
377	do	do	B-17	1879	Bored, 7-inch	46	46	64	28	64	Gas, artesian		675.00	Irrigation	†10
378	Orange County	do	A-17	1901	Hydraulic, 3-inch	47	47	120			Artesian			Roads	
379	do	do	A-17	1901	do	48	48				do			do	
380	Mrs. B. A. Hazard	do	A-17	1878	Bored, 7-inch	46	46	135		64	do			Domestic; irrigation.	9
381	A. D. Bishop	do	A-17		Bored, 4-inch	46	46		27	64	do			Domestic	2
382	do	do	A-17		Bored, 7-inch	45	45	139	29	63	do			Irrigation	24
383	S. J. Murdock	do	A-17	1890	do	46	46		27	63	do			do	

391	W. J. Edwards	do	A-17		do	46	46		27	59	do			do	
392	C. L. Williams	do	A-17		do	46	46		32	65	do			do	2
393	D. W. Osburn	do	A-17	1882	do	45	45	110	31	65	do			Domestic; irrigation.	14
394	J. J. Pyle	do	A-17	1874	Bored, 7-inch	45	45	80	33	65	Hand, artesian			Domestic	
395	do	do	A-17	1899	Hydraulic, 2-inch	45	45	107	35	64	Artesian	36.00		Irrigation	1
396	F. Wright	do	A-17	1900	Bored, 7-inch	44	44	100	32	65	do			Domestic; irrigation.	4
398	I. Chapman	do	A-17		do	45	45	96	33	65	do			Irrigation	8
400	Mrs. L. J. Hosking	do	A-17		Bored, 4-inch	48	48	55	29	65	do			do	5
401	do	do	A-17		Hydraulic, 2-inch	48	48	94	33	64	do			do	3
402	J. C. Joplin	do	A-16		Bored, 6-inch	49	49	84	31	64	do			Domestic	
403	do	do	A-16		Bored, 7-inch	49	49	190	29	64	do			Irrigation	1
404	do	do	A-16		do	49	49	200+	28	64	do			do	1
405	L. Wade	Santa Ana	H-16	1884	do	176		160	37		Wind			Domestic	
406	Mrs. Thompson	do	H-16	1900	Bored, 10-inch	192	25	167			Not raised	400.00		Not used	
407	F. M. Stocking	do	H-15		Bored, 7-inch	195		99	36		Wind			Domestic	
408	C. H. Morse	do	H-16	1890	do	175	117	140	32	65	do			do	
409	Wm. Pilcher	do	H-16	1897	Hydraulic, 2-inch	170		178			Not raised			Not used	
410	J. M. Morrison	do	H-16	1884	Bored, 7-inch	182	134	114	44		Hand			Domestic	
411	C. Oehlke	do	I-16		Bored, 8-inch	201		175	30		Gas			do	†7
412	H. W. Schoepf	do	I-16	1884	Bored, 6-inch	192	112	115	31		Wind			do	
413	A. L. Havens	do	I-16	1894	Bored, 7-inch, 66 feet; 6-inch, 66 to 120 feet.	182		126	37	64	do			do	
414	A. Schildmeyer	do	I-16	1894	Hydraulic, 2-inch	200	124	183	38		do	+ 200.00		do	
415	D. F. Campbell	do	I-16	1894	Bored, 7-inch	210		106	38		do			do	
416	A. H. Bibber	do	I-15	1884	do	225	146	122	39		do			do	
417	Geo. Acheson	do	I-15		do	210			38		do			do	
418	E. Arrowsmith	Los Alamitos	A-16		do	48	48	240	29	65	Artesian			Irrigation; stock	

Wells in the Anaheim quadrangle—Continued.

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						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
472	J. D. Chaffee	Las Bolsas	C-16		Bored, 7-inch	85			31	64	Wind			Domestic	
473	A. J. Chaffee	do	C-16	1880	Bored, 4-inch	85	70	118	30	64	do			do	
474	Mrs. Esterbrook	do	C, D-16	1882	Bored, 7-inch	87	71	132	27	64	Wind, hand			do	
475	James Sturgess	do	D-16	1880	do	84	71	112	31	64	Hand			do	
476	W. W. Sterns	do	C-15	1890	do	83	71		27		Wind			do	
477	G. W. Ramsey	do	C-15	1890	Bored, 6-inch	83		148	29	65	Hand			do	
478	Harvey Miller	do	C-16	1895	Bored, 4-inch	83	71	160	31		Gas	*$800.00		Domestic; irrigation.	†40
479	Thos. Lyons	Los Alamitos	C-16		Bored, 7-inch	82	70	160	31	64	Hand			Not used	
480	W. Chaffee	do	B, C-15	1897	do	82	70	150			do			do	
481	R. H. Pulley	do	B-16	1882	do	76	64	146	31	65	Gas		$500.00	Irrigation	†60
482	Mr. Herman	do	B, C-15		do	78	66	161	31	65	Hand			Domestic	
483	L. A. Preston	Los Coyotes	C-15	1902	Hydraulic, 2-inch	88	68	92			Gas	40.00	150.00	Irrigation	
484	do	do	C-15	1895	do	88	68	150	27		Wind	60.00	40.00	Domestic	
485	do	do	C-15	1890	Bored, 7-inch	88	68	98	29	65	Hand			do	
486	E. A. Preston	do	C-15	1902	Hydraulic, 2-inch	86	68	92	29	65	Wind	40.00		Domestic; irrigation.	
487	do	do	C-15	1903	Bored, 7-inch	100	73	165			Gas	163.00	600.00	Irrigation	
488	do	do	C-15	1903	do	100	73	44			do			do	
489	Frank Wayman	do	C-15	1890	do	89	69	146	31	65	do	*1,250.00		do	†30
490	O. E. Heathe	do	C-15	1880	Bored, 6-inch	89	68	105	29	64	Wind			Domestic	
491	Garden Grove	do	C-15	1876	Bored (2), 7-inch	88	73	140			Gas	140.00	1,800.00	Irrigation	†100
492	Irrigation Co														

441	Oliver Hill	do	B-15	1892	do	60	53	200	30	64	Hand	*252.00		Stock	
442	do	do	A-15	1890	Dug, 4 by 4 foot	58		10	51	62	do			do	
443	Mrs. A. Becket	do	B-15	1878	Bored, 7-inch	62	55	184	34		Wind			Domestic	
444	Alfred Beckett	do	B-15	1884	do	64	54	230	29		do			Domestic; irrigation.	
445	S. F. Everett	do	B-16	1876	do	64		145	31	64	do			Domestic	
446	do	do	B-15	1895	Hydraulic, 3-inch	64			38		do			Stock	
447	J. C. McLain	do	B-15	1880	Bored, 7-inch	62	54	151	30	62	Hand			Domestic	
448	Mrs. L. H. Armstrong	do	B-15	1880	do	62	54	158	31	64	do			do	
449	D. L. Leverdeau	do	B-15		Bored, 4-inch	61	54	158	30		Wind			Domestic; irrigation.	
450	R. Herren	do	B-15	1884	Bored, 7-inch	61	56	145	31	64	do			Domestic	
451	do	do	B-15	1884	do	61	56	145			Not raised			Not used	
452	T. Y. Long	do	B-15	1884	do	68	56	170	31		Gas		500.00	Domestic; irrigation.	†45
453	Frank M. Rogers	do	B-15		Bored, 4-inch	73	60	180	31		Wind			do	
454	R. C. Young	do	B-16		Bored, 7-inch	74			31		do			do	
455	H. C. Parmley	do	B-16	1903	do	70	62	165	29	65	Gas	*1,200.00		Irrigation	†90
456	do	do	B-16	1903	do	70	62	165	29	65	do			do	
457	H. A. Young	do	B-15	1904	do	68	58	176	29	66	Hand	175.00		Not used	
458	do	do	B-15	1890	Driven, 1¼-inch	61		14	51	65	do			Domestic	
459	do	do	B-15		Bored, 7-inch	69	59	175			Not raised				
460	D. McMillian	do	B-16	1889	do	70	62	158	29	65	Hand			Domestic	
461	D. Nichols	do	B-16	1884	do	71	62	160	31	65	Wind			Domestic; irrigation.	
462	do	do	B-16	1889	Hydraulic, 2-inch	70	62	160			Not raised				
463	D. K. Sanford	do	B-16	1892	Bored, 7-inch	71	62	156	31	64	Wind			Domestic; irrigation.	
464	O. B. Baxter	do	C-16	1889	Bored, 6-inch	73	62	148	29		Horsepower			do	
465	David Burkhart	do	C-16	1880	Bored, 7-inch	76	66	148	31	65	Hand			Domestic	
466	F. G. Steward	Las Bolsas	C-16	1884	do	85	69	200	31	65	Wind			do	
467	E. A. Chaffee	do	C-16	1878	do	85	75	146	33		do			do	
468	J. Dement	do	G-16	1887	do	82	76	126	31	65	Horsepower			Domestic; irrigation.	
469	D. W. Lawton	do	C-16	1880	do	76	60	158	28		Wind			do	
470	W. McCullough	do	C-16	1874	do	87			29		do			do	
471	J. W. Hill	do	C-16	1884	do	85	78	124	31	64	do			Domestic	

Wells in the Anaheim quadrangle—Continued.

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						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
472	J. D. Chaffee	Las Bolsas	C-16		Bored, 7-inch	85			31	64	Wind			Domestic	
473	A. J. Chaffee	do	C-16	1880	Bored, 4-inch	85	70	118	30	64	do			do	
474	Mrs. Esterbrook	do	C, D-16	1882	Bored, 7-inch	87	71	132	27	64	Wind, hand			do	
475	James Sturgess	do	D-16	1880	do	84	71	112	31	64	Hand			do	
476	W. W. Sterns	do	C-15	1890	do	83	71		27		Wind			do	
477	G. W. Ramsey	do	C-15	1890	Bored, 6-inch	83		148	29	65	Hand			do	
478	Harvey Miller	do	C-16	1895	Bored, 4-inch	83	71	160	31		Gas	*$800.00		Domestic; irrigation.	†40
479	Thos. Lyons	Los Alamitos	C-16		Bored, 7-inch	82	70	160	31	64	Hand			Not used	
480	W. Chaffee	do	B, C-15	1897	do	82	70	150			do			do	
481	R. H. Pulley	do	B-16	1892	do	76	64	146	31	65	Gas		$500.00	Irrigation	†60
482	Mr. Herman	do	B, C-15		do	78	66	161	31	65	Hand			Domestic	
483	L. A. Preston	Los Coyotes	C-15	1902	Hydraulic, 2-inch	88	68	92			Gas	40.00	150.00	Irrigation	
484	do	do	C-15	1895	do	88	68	150	27		Wind	60.00	40.00	Domestic	
485	do	do	C-15	1890	Bored, 7-inch	88	68	98	29	65	Hand			do	
486	E. A. Preston	do	C-15	1902	Hydraulic, 2-inch	86	68	92	29	65	Wind	40.00		Domestic; irrigation.	
487	do	do	C-15	1903	Bored, 7-inch	100	73	165	..		Gas	163.00	600.00	Irrigation	
488	do	do	C-15	1903	do	100	73	144	..		do			do	
489	Frank Wayman	do	C-15	1890	do	89	69	146	31	65	do	*1,250.00		do	†80
490	O. E. Heathe	do	C-15	1880	Bored, 6-inch	89	68	105	29	64	Wind			Domestic	
491	Garden Grove Irrigation Co	do	C-15	1876	Bored (2), 7-inch	88	73	140	..		Gas	140.00	1,800.00	Irrigation	†100

493	J. W. Hawkins	do	C-15		Hydraulic, 2-inch	88	73	100	29	65	Hand			Domestic		
494	E. J. Ware	do	D-15	1877	Bored, 7-inch	100	74	185	35		Gas	400.00	830.00	Irrigation		†40
495	F. M. Adams	do	D-15		Bored, 6-inch	94			32	65	Wind			Domestic		
496	Mrs. H. A. Warner	do	D-16	1877	Bored, 7-inch	87		212	35		Gas		700.00	Irrigation		†45
497	J. M. Woodruff	do	D-16	1890	do	85	73	189	31	65	Hand			Domestic		
498	Henry Assop	do	D-16	1903	Bored, 11-inch	90	74	98	28		Gas		165.00	Irrigation		†20
499	do	do	D-16	1896	Bored, 2-inch	90	76	100			Flows into pit	25.00		do		
500	E. Cochran	do	D-15	1894	Bored, 7-inch	95	75	140	30	65	Gas		385.00	Irrigation; domestic.		†20
501	O. A. Moody	do	D-14	1902	Hydraulic, 2-inch	95	77	106	30		Wind			Domestic; irrigation.		
502	do	do	D-16	1902	do	95	97	104	26		do			Domestic		
503	A. J. Newsome	do	D-16	1894	Bored, 7-inch	101	80	116	31	64	Gas, wind			Irrigation; domestic.		†10
504	do	do	D, E-16	1882	do	98	80	109			Not raised					
505	G. S. Martin	do	E-16	1894	do	105	87	104	31	64	Hand			Domestic		
506	W. M. Mills	do	E-16	1892	Bored, 4 inch	107	90	102	31		Wind			do		
507	Mrs. S. M. Mills	do	E-16	1872	Bored, 7-inch	104	88	133	31		do			Domestic; irrigation.		
508	S. Penfold	do	E-15	1904	Bored, 10-inch	10	90	120	34	65	Hand			Domestic		
509	J. L. Roach	Las Bolsas	E-16		Hydraulic, 2-inch	114	84	80	30		Wind			do		
510	B. Y. Duke	do	E-16	1891	Bored, 7-inch	14			32		do			do		
511	John McMillian	do	E-15	1902	Bored, 4-inch	112	92	94	31		do			do		
512	Hugh Rule	do	E-15	1892	Bored, 7-inch	19	88	107	35		do			do		
513	R. L. King	do	E-15	1903	Hydraulic, 4-inch	118	88	98	30	65	do	65.00	30.00	Domestic; irrigation.		
514	A. Carmicael	do	E-15	1898	Bored, 7-inch	120		116	31		do	100.00	+210.00	do		
515	I. B. Luther	do	E-15	1904	Bored, 4-inch	120		109	33	65	Hand			Domestic		
516	do	do	E-15	1902	Bored, 10-inch	124	87	134			Gas	125.00	1,950.00	Irrigation		†90
517	do	do	E-15	1901	Hydraulic, 2-inch	124	87	104	35	65	Hand	40.00		Domestic		
518	W. E. Schnitger	do	D-15	1899	Bored, 7-inch	102	77	106	33		Wind, gas			do		
519	do	do	D-15	1900	Bored, 9½-inch	105	78	143	31	62	Gas			Irrigation		
520	do	do	D-15	1901	Bored, 7-inch	105	78	155			do		1,500.00	do		126
521	A. A. Schnitger	do	D-15	1884	do	102	77	130	35	64	Hand			Domestic		
522	C. Holt	do	D-15	1897	Hydraulic, 2-inch	106	79	98	35		Wind			do		
523	J. Parks	do	E-15	1901	Bored, 7-inch	110	81	125	31		do			do		
524	R. J. Thompson	do	E-15	1903	do	115	80	114	33	62	Hand	104.00		do		

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
525	E. J. Minyard	Las Bolsas	E-15	1900	Hydraulic, 2-inch	110	78	87	23	65	Wind	$50.00	+$135.00	Domestic	
526	C. E. Lighthall	do	E-15		Bored, 4-inch	111	78	110	38		do			do	
527	F. A. Nelson	do	E-15	1898	Bored, 7-inch	117		168	29		do	160.00	60.00	Domestic; irrigation.	
528	C. Christensen	do	D-15		do	106	76	140	31		Gas		220.00	Domestic	
529	do	do	D-15	1900	do	108	78	154			do	155.00	1,250.00	Irrigation	†90
530	do	do	D-15	1900	do	108	78	132			do			do	
531	E. P. Fowler	do	D-14	1895	do	114	78	150			do			do	
532	do	do	D-14	1896	do	114	78	271			do			do	123
533	do	do	D-14	1897	Bored, 10-inch	114	78	150			do			do	
534	do	Los Coyotes	C-14	1899	Bored, 7-inch	103	76	160			do			do	
535	do	do	C-14	1899	do	103	76	150			do			do	96
536	do	do	C-14	1900	Bored, 8-inch	103	76	179	36		Gas, wind			Irrigation; domestic.	
537	do	do	C-14	1901	Bored, 7-inch	103	76	138	37		Wind			Domestic	
538	W. A. Newbery	Las Bolsas	D-14	1897	Bored, 10-inch	105	78	187			Gas			Irrigation	
539	do	do	D-14	1897	Bored, 7-inch	105	78	187	31	65	do		1,000.00	do	†108
540	do	do	D-14	1902	do	105	78	188			do			do	
541	Albert Bruskey	do	D-14, 15	1901	do	107	78	141	31	65	do	175.00	825.00	do	†85
542	P. B. Roy	do	E-15	1903	do	117	83	126			do		2,200.00	do	†135
543	do	do	E-15	1903	do	117	83	140			do			do	
544	do	do	E-15	1903	Bored, 6-inch	117	83	160	31		do			Domestic; stock	98
545	W. W. Mewter	do	E-14	1901	Bored, 10-inch	120	81	131	29			165.80	1,596.00	Irrigation	

551	.....do.....	.....do.....	E-14, 15	.....	Bored, 7-inch....	119	.....	.....	35	....	.....do.....	.....	150.00	Domestic.....	.....
552	L. H. Wilcox.....	San Juan Cajon...	E-13....	1903	Hydraulic, 3-inch	135	.....	98	27	....	Wind.....	.....	.....	.....do.....	.....
553	Hugh Grice.....	.....do.....	D-14....	1901	Bored, 7-inch....	112	82	138	31	....	.....do.....	.....	.....	.....do.....	.....
554	J. B. Neff.....	.....do.....	E-14....	1894	.....do.....	135	88	100	....	....	Steam.....	90.00	2,800.00	Irrigation.....	†150
555	.....do.....	.....do.....	E-14....	1898	.....do.....	135	88	100	....	....	.....do.....	105.00		.....do.....	
556	.....do.....	.....do.....	E-14....	1897	.....do.....	134	89	113	32	65	Wind.....	108.00	.....	Domestic.....	.....
557	W. L. Knowlton.....	.....do.....	E-13....	1901	.....do.....	135	89	105	....	....	Gas.....	*1,200.00	.....	Irrigation.....	†40
558	.....do.....	.....do.....	E-13....	1903	Bored, 4-inch....	133	.....	96	33	65	Hand.....	32.00	.....	Domestic.....	.....
559	Elizabeth Enearl.....	Las Bolsas.....	D-14....	1894	Bored, 7-inch....	120	82	110	36	....	Wind.....	94.00	.....	.....do.....	.....
560			D-14....	1902	.....do.....	120	82	149	....	....	Gas.....	114.00	1,500.00	Irrigation.....	†75
561	F. Newhall & Son....	.....do.....	C-14....	.....	.....do.....	105	78	.....	....	....	Wind.....	.....	.....	Domestic.....	.....
562	A. E. Nutt.....	Los Coyotes.....	C-14....	1901	.....do.....	105	78	165	....	....	Gas.....	*2,000.00	.....	Irrigation.....	†80
563	.....do.....	.....do.....	C-14....	1901	.....do.....	105	78	169	....	....	.....do.....				
564	W. E. Case.....	Las Bolsas.....	D-15....	1897	.....do.....	104	78	148	32	64	Hand.....	.....	.....	Domestic.....	.....
565	Gray Bros.....	.....do.....	D-15....	1897	Hydraulic, 2-inch	104	78	136	31	64	Wind.....	.....	.....	Irrigation.....	.....
566	.....do.....	.....do.....	D-15....	1900	Bored, 7-inch....	104	78	247	....	....	.....do.....	.....	.....	.....do.....	.....
567	J. W. Cornelison.....	Santa Ana.....	H-15....	1899	Dug, 3-foot diameter.	202	124	85	42	....	.....do.....	.....	.....	Domestic.....	.....
568	H. Bergemann.....	.....do.....	I-15, 16..	1900	Bored, 7-inch....	208	105	115	....	....	.....do.....	.....	.....	.....do.....	.....
569	H. Nieffer.....	.....do.....	I-15, 16..	.....	.....do.....	208	.....	.....	42	....	.....do.....	.....	.....	.....do.....	.....
570	Mrs. M. L. Travis.....	.....do.....	I, J-15 ..	1896	.....do.....	228	.....	120	41	....	.....do.....	125.00	+250.00	.....do.....	.....
571	J. C. Hyle.....	.....do.....	I-15.....	1897	.....do.....	228	.....	119	33	....	.....do.....	.....	.....	.....do.....	.....
572	Geo. Schmidchen.....	.....do.....	J-15	1901	.....do.....	228	.....	131	47	....	.....do.....	135.00	.....	.....do.....	.....
573	Chas. Harter.....	.....do.....	J-16	1897	.....do.....	223	.....	138	42	....	.....do.....	200.00	.....	.....do.....	.....
574	W. F. Kaiser.....	.....do.....	J-15	1901	.....do.....	235	101	138	44	....	.....do.....	.....	.....	.....do.....	.....
575	D. C. Drake.....	.....do.....	I-15.....	.....	.....do.....	226	111	118	42	....	.....do.....	.....	.....	.....do.....	.....
576	A. H. McCollum.....	.....do.....	I-15.....	1897	.....do.....	225	.....	119	39	....	.....do.....	.....	.....	Domestic; irrigation.	.....
577	A. F. Schubert.....	.....do.....	I-15.....	1897	.....do.....	224	.....	125	34	....	.....do.....	*300.00	.....	Domestic.....	.....

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
578	Orange City Water Company.	Santa Ana	I-15		Bored, 9-inch	206	104	120			Gas			Not used	
579			I-15	1902	Bored, 12-inch, 440 feet. Bored, 10-inch, 180 feet.	230	121	620			Steam			Domestic	2
580	H. Fitchen	do	J-15	1900	Bored, 7-inch	248	125	148	44		Wind			do	
581	Henry West	do	J-15	1880	Dug, 2½-foot diameter.	250	125	128			do			do	
582	H. S. Grenenwald	do	L-15	1900	Bored, 7-inch	320	276	85	42		Gas			Domestic; irrigation.	†12
583	Perkins Bros	do	K-14	1900	do	276	91	247	56		do	$302.80	$1,150.00	do	†17
584	R. Emmick	do	H-15	1884	do	165	103	80	52	65	Hand			Domestic	
585	Mrs. C. R. Bush	do	H-15	1896	do	165	100	66	58		Wind			do	
586	Iven Ruck	do	H-15	1899	do	165		118	27		Hand			do	
587	W. A. Morrison	do	H-15	1894	do	165		128	33		do			do	
588	Mrs. Thos. Goss	do	H-14	1901	do	165	105	142	35		Gas			Domestic; irrigation.	
589	T. P. March	do	H-14		do	170			48		Wind			do	
590	H. Loptien	do	H-14	1870	do	170	100	74	51	65	do			Domestic	
591	Fred W. Struck	do	H-14	1894	do	168	102	72	49	65	do			do	
592	H. Rensch	do	H-14	1882	do	166	105	66	47		do			do	
593	R. Paulus	do	H-14	1902	do	165	105	70	52	65	Hand			do	
594	Max Struck	do	H-14	1902	do	167		72	42	65	Wind			do	
595	Fred Gerken	do	H-14	1900	do	165		72	45		do				

															tion.	
597	W. Raugh	do	I-15	1898	do	205		95	42		do			Domestic		
598	Mrs. C. P. Mallory	do	I-14	1900	do	208		140	42		do			do		
599	F. H. Hollister	do	I-14		do	193	112	87	38		do			do		
600	C. S. Spencer	do	I-14	1896	do	188		129	33		do			do		
601	Henry Bosch	do	I-14		do	193			35	65	Hand			do		
602	Henry Rodieck	do	I-14	1901	do	191			39		Wind			do		
603	S. S. Raugh	do	I-14	1902	do	180		142	37		do			do		
604	O. Dowens	do	I-14		do	185	85	128	31		do			do		
605	A. C. Elliott	do	I-14	1890	do	195	95	142	29		Gas			Domestic; irrigation.		
606	C. F. Johnson	do	I-14	1903	do	200	92	128	38		Wind	200.00	+400.00	Domestic		
607	Chas. Carlson	do	I-14	?1882	Bored, 6-inch	207	100	100	40		do			do		
608	S. M. Davis	do	I-14	1901	Bored, 7-inch	213		110	39		do			do		
609	J. W. Rice	do	I-15		do	215		150	40		do			do		
610	John Hanson	do	I-15	1897	do	220		117	35		do			do		
611	J. H. Kurtz	do	I-15	1902	Dug, 3-foot diameter.	225	126	104	32		Hand			do		
612	Rob Apple	do	I-15	1900	Bored, 7-inch	224		122	37		Wind	145.00		do		
613	G. D. Toothaker	do	I-14	1900	do	218	118	130	38		do	195.00	80.00	do		
614	William Bierwagen	do	J-14	1900	do	232	100	147	37		do	150.00		do		
615	A. N. Saxton	do	J-15	1903	do	237	147	130	37	65	do			do		
616	R. S. Williams	do	J-15	1897	do	258	119	140			Not raised					
617	G. W. Brown	do	J, K-13, 14.	1899	Dug, 3 by 3 foot, 180 feet; bored, 7-inch, 12 feet.	298	98	200	43		Wind			Domestic		
618	C. O. Field	do	J-13, 14	1902	Dug, 3-foot diameter.	285	233	53	39	66	Hand			do		
619	Geo. Jesson	do	J-13		Bored, 7-inch	296	dry	161			Not raised					
620	J. P. Williams	do	K-13	1901	Dug, 3-foot diameter.	325	dry	210			Hand					
621	Villa Park school district.	do	K-14		Bored, 7-inch	300	100	225			Wind			Domestic		
622	S. A. Gilbert	San Juan Cajon	F-14	1901	do	135	95	122	35	65	do			Domestic; irrigation.		
623	A. P. Smith	do	F-14	1899	do	132	92	112	30		do			do		
624	John Wheaton	do	F-14	1897	Hydraulic, 2-inch	130	89	108			do	40.00		do		

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
625	J. M. Willoughby	San Juan Cajon	F-14	1904	Driven, 2-inch	133	87	80	29	65	Gas			Domestic	
626	do	do	F-14	1904	Bored, 10-inch	133	87	125			Not raised at present.				
627	S. M. Wren	do	F-14	1900	Bored, 7-inch	135		107	33		Wind	$105.00		Domestic	
628	J. B. Bowman	do	F-14	1904	Bored, 10-inch	139	87	102	32	62	Gas	275.50	$1,000.00	Irrigation	†35
629	A. Warner	do	E-14	1901	do	125	85	127			do	*1,500.00		do	†60
630	J. B. Ray	do	E-14	1901	do	127	84	115			do	202.00	1,300.00	do	†80
631	do	do	E-14	?1882	Bored, 4-inch	127	84	90	44		Wind			Domestic	
632	G. C. Hiatt	Las Bolsas	D-14	1900	Bored, 7-inch	120	84	198			Gas	*1,800.00		Irrigation	†125
633	do	do	D-14	1900	do	120	84	150			do			do	
634	do	do	D-14	1904	do	120	84	145			do			do	
635	do	do	D-14	1898	do	115	81	108	40		Wind			Domestic	
636	O. E. Cheesebrough	Los Coyotes	C-14		do	98	76	100	52	67	do			do	
637	do	do	C-14		do	98	75	96			do			Irrigation	
638	T. J. Jones	do	C-14	1890	do	86	74	260	43	66	do			Domestic	
639	do	do	C-14	1900	do	101	82	165			Gas	*1,400.00		Irrigation	†70
640	W. J. Hill	do	C-15	1885	Bored, 8-inch	87	69	100	36		do			Domestic	
641	do	do	C-15	1875	Bored, 7-inch	87	69	170			Steam			Irrigation	†70
642	S. Christensen	Los Alamitos	C-15	1885	do	82	65	176	31	65	Wind			Domestic	
643	C. N. Brown	Los Coyotes	B-15	1880	do	79	67	181	34	66	Hand			do	
644	F. A. Gates	do	B-15	1898	Hydraulic, 2-inch	77	67	140	38	64	Wind			Domestic; irrigation.	
645	Mrs. Nellie Town	do	B-15	1877	Bored, 7-inch	77	67	180	38	65	do			do	

650	....do	....do	E-14	1904	....do	128	86	131	25	62	....do		....do	
651	A. R. Dresser	Santa Ana	H-17	1888	....do	150		58	46		Wind		Domestic	
652	Otis Jones	....do	H-17	1889	....do	150		59	56		....do		....do	
653	H. M. Seyor	....do	H-17	1889	....do	150		56	49		....do		....do	
654	J. Chandlier	....do	H-17	1888	....do	135	90	65	49		....do		Domestic; irrigation.	
655	J. H. Sharp	....do	K-16	1900	Bored, 9½-inch	200	83	136	43	66	Hand		Domestic	
656	H. M. Morse	....do	H-17	1900	Bored, 7-inch	162		90	43		Wind, gas		Domestic; irrigation.	
657	J. A. Oderlin	....do	I-17	1888	....do	161	100	65	53		Wind		Domestic	
658	H. W. Sylvester	....do	H 17		....do	141	93	58			....do		Domestic; irrigation.	
659	M. A. Kiefhaber	....do	M-14	1892	Dug, 2 by 2 foot	475	460	21	57		....do		Domestic	
660	J. N. Long	Los Coyotes	B-15	1903	Bored, 7-inch	80	65	170	45		....do		....do	
661	....do	....do	B-15	?1882	....do	80	65	170			Gas		Irrigation	†90
662	....do	....do	B-15	1902	....do	80	65	161			....do		....do	
663	S. S. Ball	....do	C-14		Bored, 4-inch	94			32	65	Wind		Domestic	
664	Ruben Kidner	....do	C-14		Hydraulic, 2-inch	98			41	65	Hand		....do	
665	S. S. Ball	....do	C-13		Bored, 10-inch	105	77	145	34	65	Gas		Irrigation	†90
666	....do	....do	C-13	1901	....do	105	77	145	34	65	....do		....do	
667	W. R. Clark	....do	B-13		Bored, 4-inch	88	72	100	21	66	Wind		Domestic	
668	....do	....do	C-13	1904	Bored, 7-inch	92	72	175			Gas		Irrigation	
669	....do	....do	C-13	1904	....do	92	72	176			....do		....do	
670	P. A. Stanton	....do	B-14		Bored, 3-inch	87			34	65	Hand		Stock	
671	W. A. Blizzard	....do	B-13	1901	Hydraulic, 2-inch	85	70	147	35	65	Wind	100.00	Domestic	
672	J. M. Gilbert	....do	B-14	1897	....do	80		96	45		....do		....do	
673	....do	....do	B-14	1897	....do	80		495			....do		....do	
674	....do	....do	B-13	1902	....do	80		108	35	65	Hand		Stock	
675	W. J. Thompson	....do	B-14	1892	Driven, 1¼-inch	74		35	32	65	....do		Domestic	
676	A. Barter	....do	B-14	1894	Bored, 7-inch	72	60	168	25	64	Wind		Domestic; irrigation.	
677	....do	....do	B-14	1898	Hydraulic, 2-inch	72	60	533	28	64	Hand		....do	

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
678	W. H. Kennedy	Los Coyotes	B-14	?1882	Bored, 7-inch	73	62	183	33	65	Gas	*$1,000.00		Irrigation	68
679	....do	....do	B-14	1904	....do	73	62	183	33	65	....do			....do	
680	J. H. Brown	....do	B-14	1897	Hydraulic, 2-inch	73	62	265			Not raised				
681	De Los Marton	....do	B-14	1904	Bored, 7-inch	72	62	146	32	65	Wind	145.00		Domestic	
682	James Kearns	....do	B-14	1899	Hydraulic, 2-inch	72	62	276	32	65	....do			Domestic; irrigation.	
683	T. Hill	....do	B-14	1892	Driven, 1¼-inch	72		42	33	65	Hand			Domestic	
684	....do	....do	B-14	1897	Hydraulic, 2-inch	72	62	267	32	65	Wind			Domestic; irrigation.	
685	L. Hickox	....do	B-14		Driven, 1¼-inch	71		14	27	65	Hand			Domestic	
686	J. Snow	....do	B-14	1894	Bored, 4-inch	70	63	224	32		Wind			Domestic; irrigation.	
687	J. J. Hayes	Los Alamitos	B-15	1897	....do	69	60	200	31	65	Hand			Domestic	
688	J. Corner	....do	B-15	1896	Hydraulic, 2-inch	70	64	200+	40		Wind			....do	
689	J. W. McClellen	Los Coyotes	C-14	1900	Bored, 7-inch	87	67	158			Gas	*1,400.00		Irrigation	†100
690	....do	....do	C-14	1904	....do	87	67	172			....do	170.00		....do	
691	....do	....do	C-15	1880	....do	87	67	365	28		Wind			Domestic	
692	Mrs. M. Merideth	San Juan Cajon	E-13		Dug, 3 by 3 foot; bored, 7-inch.	137			30		....do			....do	
693	H. E. Hunt	....do	D, E-14	1903	Bored, 7-inch	126		113	33	66	Hand	100.00		....do	
694	Robert Hansen	....do	E-13	1894	Hydraulic, 2-inch	30	90	100	45		Wind	35.00		....do	
695	A. O. Luer	Las Bolsas	D-13		Bored, 7-inch	118	88	101	50		....do			....do	
696	E. J. Sparkes	....do	D-13	1894	Bored, 4-inch	18		100	46		....do			....do	
697	E. D. Merion	....do	D-13	1884	Bored, 7-inch	113					....do				

698	R. Westfall	do	D-14		do	115	85	96	58		do			do		
699	E. A. Sparkes	do	D-13	1894	do	115	84	100	68		do			do		
700	Mrs. M. Lare	Los Coyotes	B-14	1892	Bored, 4-inch	70			29	65	Hand			do		
701	A. Franklin	do	A-14	1903	Hydraulic, 3-inch	66	63	138	31	65	do			do		
702	J. E. Miller	do	A-14	1896	Hydraulic, 2-inch	66			31		Wind			do		
703	J. Everharte	do	A-14	1902	Bored, 7-inch	62	57	144	32		Hand			do		
704	J. R. Newsom	do	A-14	1897	Hydraulic, 2-inch	55	52		31	65	Wind			do		
705	J. Stearn	do	A-14		do	53			31	65	Hand			do		
706	R. Kruger	do	A-14		do	54					Wind			Stock		
707	Ludwig Kunkel	do	A-13	1903	Driven, 1¼-inch	62	54	11	84	64	Hand			Domestic		
708	C. W. Overton	San Juan Cajon	E-11		Bored, 7-inch	152	122	70	35		Wind			do		
709	G. A. Mills	do	E-10	1897	Hydraulic, 2-inch	150	122	136	30		do	40.00		do		
710	A. G. Miller	do	E-10		Bored, 4-inch	148		60+	30		do			do		
711	Ed Beasley	do	E-10	1903	do	147		135	33		do			do		
712	R. S. Gregory	do	E-10	1899	do	150			40		do			Domestic; irrigation.		
713	J. Naeger	do	E-9	1890	do	165	125	120	77		do			Domestic		
714	Orange City Water Co.	do	E-9	1886	Bored, 11½-inch	165	98	118	75		Steam			do		92
715		do	E-9	1886	Bored, 7-inch	165	98	196			Gas			Not used		
716	H. S. Russel	do	E-10	1901	do	152	124	175	75		Wind			Domestic		
717	A. Hiltscher	do	E, D-9	1898	Bored, 4-inch	150	95	154	41		Gas			Domestic; irrigation.		
718	Orange Co. Nursery	do	D-9	1899	Bored, 7-inch	148	103	191	69		Electricity			do		†12
719	A. McDermont	do	D-9	1889	do	149	99	100	39		Wind			do		
720	Geo. Fiscus	do	F-13	1890	do	144	91	95	37		do			Domestic		
721	Wm. Kalbary	Santa Ana	H-14	1901	Dug, 4-foot diameter, 64 feet; bored, 6-inch, 24 feet.	165	103	88	43		do	100.00	$45.00	do		
722	Sam. Keuchel	do	H-13	1900	Bored, 7-inch	78	13	95	43		do			do		
723	F. W. Hughes	do	H-13	1900	Dug, 30-inch diameter.	185	115	73	48		do			do		
724	Ray Krueger	do	H-13	1903	Dug, 3½-foot diameter.	187	115	75	36		Hand			do		
725	Wm. Nolbe	do	H-13	1904	do	188	118	72	38		do			do		
726	J. P. Coyne	do	I-13		Bored, 7-inch	192	112	141	37		Wind			do		
727	C. Mensen Kamp	do	I-13	?1897	do	200		114	44		do			do		

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		*F.*					*Miner's inches.*
728	J. Kurtz	Santa Ana	J-13	1898	Bored, 7-inch	234	85	158	39	....	Wind			Domestic	
729	E. Meehan	do	J-13	1902	do	133	83	165	40	....	do			do	
730	H. W. Mills	do	J-13	1896	do	137	93	160	32	....	do			do	
731	J. F. Snowden	do	J-13	1903	do	155	.....	178	39	....	Gas	$300.00		do	
732	A. P. West	do	J-13	1903	Dug, 3-foot diameter.	263	96	168	42	....	Wind	210.00		do	
733	J. B. Shoemaker	do	I, J-12	1903	do	247	144	106	53	....	do	135.00		do	
734	W. H. Bass	do	I-12	.....	Bored, 6-inch	259	Dry.	92	....	....	Not raised				
735	Olive Milling Co	do	I, J-12	1890	Bored, 7-inch	285	134	153	....	....	Steam			Domestic	
736	F. H. Meats	do	I-12	1903	do	225	118	170	47	....	Wind			do	
737	W. H. Stinchfield	do	I-12	1902	Dug, 3½ by 3½ feet; bored 8-inch, 20 feet.	222	115	106	49	....	do			do	
738	D. P. Crawford	do	I-11	1896	Bored, 7-inch	220	126	106	46	....	do			do	
739	Mary L. Paine	do	I-12	1903	do	215	.....	124	45	....	do			do	
740	A. Peck	do	I-13	1894	do	196	146	155	37	....	do			do	
741	Olive road district	do	I-13	1901	do	198	111	186	37	....	Gas	240.00	$450.00	Roads	
742	H. Heim	do	I-12	1901	do	225	115	150	43	....	Wind			Domestic	
743	J. Timken	do	I-12	1904	do	209	111	118	....	....	Gas	177.00	150.00	do	
744	Taylor Bush	do	I-12	1900	Dug, 3-foot diameter.	206	110	98	51	....	Wind	49.00	85.00	do	
745	J. D. Heitshusen	do	H-12	1902	Dug, 3½ by 3½ feet, 90 feet; bored, 7-inch.	203	107	100	51	....	do			do	

746	A. H. Robert	do	H-12	1903	Dug, 3-foot diameter, 90 feet; bored, 7-inch, 30 feet.	199	110	120	46	do	186.26	55.00	do				
747	Wm. Robbins	do	H-12	1899	Bored, 7-inch	197	Dry	95		Hand			do				
748	E. Tetzlaff	do	I-12	1902	Dug, 3 by 3 feet	199	Dry	85		do			do				
749	J. R. Fletcher	do	I-12	1889	Bored, 7-inch	201	101	117	46	Wind			do				
750	Ben Dierker	do	H-12, 13	1902	Dug, 3-foot diameter.	196	108	90	32	do	85.00		do				
751	Paul Gatzke	do	H-13		Bored, 7-inch	194	Dry	86	32	do			do				
752	F. E. Robertson	do	H-13	1903	Dug, 3-foot diameter.	194	192	90	32	Hand			do				
753	Mrs. H. Adler	do	H-12	1898	Bored, 7-inch	195	95	103	42	Wind			do				
754	G. Kloth	do	H-13	?1889	do	183		95	38	Hand			do				
755	John Borchard	do	H-13	1901	Dug, 3-foot diameter, 60 feet; bored, 7-inch, 22 feet.	192	112	82	53	do			do				
756	T. M. Flippen	do	H-13	1893	Bored, 7-inch	183	102	100	43	do			do				
757	John Bunke	do	H-13	?1890	do	184		100	37	Wind; hand			do				
758	Jacob Bargsten	do	H-14	1891	do	172	103	72	41	Wind	98.00		do				
759	J. P. Kindt	San Juan Cajon	G-14	1900	Dug, 4-foot diameter.	159	92	69	40	do	95.00		do				
760	S. Hemmering	do	G-13	1903	Bored, 7-inch, 70 feet; 3-inch, 5 feet.	163	95	75	37	do	28.00		do				
761	J. A. Smith	do	F-14	1900	Bored, 10-inch	155	86	150	33	Gas	371.00	1,542.00	Irrigation	†60			
762	do	do	F-14	1902	Bored, 7-inch	152		71	38	Wind	89.00	40.00	Domestic				
763	I. Clemens	do	F-14	1902	Bored, 10-inch	145	89	127		Gas	300.00	1,400.00	Irrigation	†70			
764	do	do	F-14	1903	Bored, 7-inch	143	92	102	38	Hand	100.00	30.00	Domestic				
765	Wm. Green	do	F-14	?1884	do	141	90	86		Wind			do				
766	John Hanna	do	F-14		do	141	90	97	35	do			do				
767	Joe Fiscus	do	F-13	1897	Bored, 10-inch	146	92	123		Gas	166.70	1,775.00	Irrigation				
768	do	do	F-13	1901	Bored, 9½-inch	146	92	122		do	166.70		do				
769	Orange County	do	F-13		Bored, 7-inch	146	91	94	36	Wind			Roads				
770	Wm. Pannier	do	F-13	1897	do	152	92	75	44	do	72.00		Domestic				
771	do	do	F-13	1904	Bored, 10-inch	158	93	119		Gas			Irrigation				
772	do	do	F-13	1904	do	158	93	130		do			do				

Wells in the Anaheim quadrangle—Continued.

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						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
773	Wagner Bros	San Juan Cajon	G-12	1902	Bored, 10-inch	185	101	109	....	....	Gas	$158.00	.....	Irrigation	†50
774	.....do	.....do	G-12	1904	.....do	185	101	122	....	....	.....do	85.00	.....	.....do	
775	P. A. Dargett	.....do	G-12	1903	Bored, 7-inch	181	106	162	40	....	Hand	120.00	.....	Domestic	.....
776	Mrs. M. E. Stanley	.....do	G-12	1903	Bored, 6-inch	180	.....	88	38	....	Wind	.....	.....	.....do	.....
777	W. W. Scott	.....do	G-12	1884	Bored, 7-inch	181	103	85	40	....	.....do	.....	.....	.....do	.....
778	.....do	.....do	G-12	1901	Dug, 6-foot diameter, 73 feet; bored, 70-inch, 30 feet.	181	103	103	45	....	Gas	217.00	.....	Irrigation	†25
779	C. D. Thompson	.....do	G-12	1901	Bored, 4-inch	182	106	80	41	....	Wind	.....	.....	Domestic	.....
780	Geo. Stanley	.....do	G-12	1897	Bored, 6-inch	183	110	85	45	.....	.....do	.....	.....	.....do	.....
781	G. Spingath	.....do	G-12	1902	Bored, 7-inch	182	.....	106	43	....	Hand	120.00	.....	.....do	.....
782	S. E. Wecker	.....do	G-12	1903	.....do	183	....	106	43	....	.....do	125.00	.....	Domestic; stock	.....
783	John Berg	.....do	G-12	1901	Bored, 4-inch	182	.....	98	....	....	.....do	100.00	.....	Domestic	.....
784	.....do	.....do	G-12	1904	Bored, 10-inch	186	105	111	....	....	Gas	200.00	$1,375.00	Irrigation	†50
785	.....do	.....do	G-12	1898	Bored, 7-inch	186	105	108	....	....	.....do	181.00		.....do	
786	Peter Berg	.....do	G-12	1902	Bored (2), 10-inch	188	106	110	42	....	Gas (2)	600.00	2,000.00	Irrigation (2)	†75
787	W. Trapp	.....do	G-11	1902	Bored, 7-inch	192	110	101	43	....	Wind	111.00	60.00	Domestic	.....
788	.....do	.....do	G-11	1904	Bored, 10-inch	197	112	104	....	....	Gas	225.00	2,400.00	Irrigation	.....
788a	.....do	.....do	G-11	1904	.....do	197	112	112	....	....	.....do	225.00		.....do	.....
789	Wm. Wagner	.....do	G-11	1887	Bored, 7-inch	185	110	80	42	....	Hand	.....	.....	Domestic	.....
790	Miller Scribner	.....do	F-13	1902	.....do	150	94	156	36	....	Gas	192.00	750.00	Irrigation	†25
791	C. L. Green	.....do	F-13	1904	.....do	153	95	101	....	....	.....do	88.07	.....	.....do	.....
792	.....do	.....do	F-13	1904	.....do	158	95	84	....	....	.....do	71.48	.....	.....do	.....

793	G. A. Hunter	do	F-12	?1879	Bored, 10-inch	164	102	248	43		do			do		85
794	do	do	F-12		Bored, 7-inch	158	99	85	39		Hand			Domestic		
795	Geo. Bauer	do	F-12	1901	Bored, 4-inch	170		99	38		do	95.00		do		
796	W. W. Terry	do	F-12	1900	do	170		83	45		Wind	65.00		do		
797	W. A. Ross	do	F-12		do	169	105	105	42		Gas			Domestic; irrigation.		
798	M. V. Stewart	do	F-12	?1900	Bored, 8-inch	172	104	106	44		do			Irrigation		†40
799	A. Gansmantel	do	F-12	?1897	Bored, 7-inch	169	104	89	42		Wind			Domestic; irrigation.		
800	H. Gebert	do	F-12	1901	Bored, 4-inch	173	105	104	46		Hand	60.00		Domestic		
801	F. M. Walber	do	F-12	1903	Bored, 7-inch	176	105	120	44		Gas		2,350.00	Irrigation		†75
802	do	do	G-12	1900	do	176	105	107	44	62	do			do		
803	do	do	F-12	?1898	do	175	106	107	43		do			Domestic		†3
804	A. H. Sheldon	do	F-12	1903	Bored, 6-inch	169	102	101			Not raised					
805	J. C. Ervines	do	F-12	1903	Bored, 4-inch	177	107	95	44		Wind	98.00	47.00	Domestic		
806	Wm. Herper	do	G-12	1903	Bored, 7-inch	179	107	100	42		Hand	100.00		do		
807	Edmund Henry	do	F-12	1901	Bored, 4-inch	178		90	48		do	*94.00		do		
808	M. L. Rogers	do	F-12		Bored, 7-inch	177	108	100	46		Wind			Domestic; stock		
809	A. Staehnke	do	F-12	1903	do	175	106	101	51		Hand			Domestic		
810	C. H. Thayer	do	F-12	1903	do	175	106	100	46		Gas	115.00	950.00	Irrigation		†25
811	Anaheim Cemetery	do	F-11		Bored, 8-inch	175	106	86	48		do			do		
812	G. L. Pickett	do	F-12	?1878	Bored, 7-inch	174	104	87	62		Wind			Domestic		
813	do	do	F-12	1901	do	174	104	108			Gas	122.00		Irrigation		†75
814	do	do	F-12	1901	do	174	104	101			do			do		
815	Mr. Fisher	do	F-12		do	169	104	86	42		Wind			Domestic		
816	L. S. Fletcher	do	F-12	1899	Bored, 4-inch	168		89	42		Wind, gas			Domestic; irrigation.		
817	M. A. Remick	do	F-12	1901	do	167	101		46		Wind			Domestic		
818	H. Kuebler	do	F-12	1898	Bored, 8-inch	167	101	96	44		do	96.00	40.00	do		
819	John Kuebler	do	F-12	1894	Bored, 6-inch	168	102	97			do	120.00		do		
820	W. T. McClellan	do	F-12	1904	Bored, 4-inch	155		80	42		Hand	54.40		do		
821	W. W. Weaver	do	F-12	1900	do	157		92	44		do	75.00		do		
822	J. Vetter	do	F-12	1902	do	157		82	43		do			do		
823	E. Kossert	do	F-12		Bored, 7-inch	158	100	83	40		Wind			do		
824	A. Schneider	do	F-12		do	154		85	41		do			do		
825	Mrs. N. J. Ramella	do	E-12	?1890	do	150	95	57			Hand			do		

Wells in the Anaheim quadrangle—Continued.

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						Feet.	*Feet.*	*Feet.*		*F.*					*Miner's inches.*
826	Oscar Renner	San Juan Cajon	E-12	1894	Driven, 1¼-inch	150		65	66		Hand			Domestic	
827	Max Früh	do	E-12	1893	Bored, 4-inch	150	96	65	47		Wind			do	
828	C. Stuckle	do	E-12	?1888	Bored, 7-inch	150	96	76	42		Hand			do	
829	do	do	F-12	1898	Bored, 4-inch	149		69	61		Wind			do	
830	D. Gervais	do	F-13	1903	Bored, 10-inch	148	93	102	39		Gas	$132.00	$2,011.00	Irrigation	†100
831	do	do	F-13	1904	do	148	93	103			do	168.00		do	
832	Mr. Kelley	do	F-13		Bored, 7-inch	135	90	79	43		Wind			Domestic	
833	J. C. Manerhan	do	F-13	?1897	Hydraulic, 2-inch	136		89	46		do	55.00		do	
834	do	do	F-13	1902	Bored, 10-inch	138	88	98			Gas	300.00	1,300.00	Irrigation	†100
834a	do	do	F-13	1902	do	138	88	104			do			do	
835	Ed. Kalf	do	F-13	1902	Bored, 7-inch	136	87	92	44		Hand	100.00		Domestic	
836	J. C. Schulz	do	F-13	1898	Bored, 3-inch	135		92	43		Wind			do	
837	Mrs. M. Newbauer	do	F-13	1902	Bored, 7-inch	130	89	99	45		do	106.00		do	
838	W. W. Mickle	do	D-13	?1890	do	129	89	100	68		do			do	
839	S. Holman	do	D-13	?1890	do	128	80	96	65		do			do	
840	A. Binder	do	D-13		do	130	89		75		do			do	
841	Fairview Water Co.	do	D-13	1903	do	131	89	308			Gas	418.00	1,930.00	Irrigation	135
842	do	do	D-13	1903	do	131	89	100			do	98.00		do	
842a	do	do	D-13	1903	do	131	89	101			do	98.00		do	
843	M. Neipp	do	D-13	1883	do	127	87	81	47		Wind	165.00		Domestic	
844	H. F. Kealiher	do	D-13	1902	do	124	83	100			Gas	160.00		Irrigation	†80
845	do	do	D-13	1903	do	123	83	100			do	160.00		do	

846	L. J. Johnson	do	D-13	1903	do	125	83	118	42		do	124.00	600.00	do	†15		
847	H. F. Kealiher	do	D-13	1897	Bored, 4-inch	127	85	98	43		Wind	83.50		Domestic			
848	A. Hurtado	do	E-12, 13	1901	Bored, 3-inch	148		73	51		Hand	71.00		do			
849	R. Hermans	do	E-12, 13		Bored, 4-inch	148		76	47		Wind			do			
850	Mrs. Merideth	do	E-13	1901	Bored, 7-inch	148	94	101	40		do			Domestic; irrigation.			
851	F. Shanley	do	E-13	1896	do	148	96	94	42		do	94.00	45.00	do			
852	John Knutzen	do	E-13	1899	Bored, 4-inch	137	95	46			do			Domestic			
853	W. Berdrow	do	E-13		Bored, 8-inch	137	90	75	41		do			do			
854	Thos. Yaeger	do	E-13	1901	Bored, 4-inch	132		90	43		do	70.00		do			
855	Wm. Schwenckert	do	E-12	1903	Bored, 7-inch	138	90	100	41		Gas	88.00		Irrigation	†100		
856	do	do	E-12	1903	do	138	90	98	41		do	86.40		do			
857	do	do	E-12	1880	do	135		90	45		Wind			Domestic			
858	P. C. Miller	do	D-12	1894	do	131	85	86	40		do	90.00		Stock			
859	do	do	D-12	?1880	do	129	84	84	43		do	90.00		Domestic			
860	G. J. Stock	do	D-13	1897	do	128	83	84	45		do	85.00		do			
861	W. R. Dickinson	do	D-13	1903	Bored, 4-inch	126		80	51		do			do			
862	A. Huch	do	D-13	1894	Bored, 7-inch	122	86	83	46		do	93.00		Domestic; stock			
863	C. G. Sparks	do	D-13	?1895	do	123	84	76	96		do			Domestic			
864	W. W. Adams	do	D-13	1898	do	125		96	86		do			do			
865	C. L. Carter	do	D-13	1900	do	120		100	80		Hand			do			
866	Mrs. Fay	do	D-13	1898	Bored, 10-inch	118		98	45		Gas, wind			do	†60		
867	do	do	D-13	1898	do	118		101	45		Gas			do			
868	B. Heald	do	D-13	1902	Bored, 7-inch	120	87	130	43	66	do	130.00	700.00	Irrigation	†35		
869	do	do	D-13	1891	Driven, 1¼-inch	120		50	43		Wind			Domestic			
870	do	do	D-13	?1894	Bored, 7-inch	121	88	100			do			Not used			
871	M. H. Litten	Los Coyotes	D-13	?1901	do	121	88	124	40		do			Domestic			
872	W. S. Tipton	do	D-12	1899	do	123		100	40		Wind, gas			Domestic; irrigation.			
873	B. W. Lentz	do	D-12	1902	Bored, 10-inch	123		137			Gas			Irrigation	†60		
874	do	do	D-12	1902	Bored, 7-inch	123		137			do			do			
875	do	do	D-12		do	122	90	120	38		Wind			Domestic			
876	C. Macy	do	C-12	1903	do	116	86	85	73		do	95.00	50.00	do			
877	M. Lee	do	C-12	1903	Bored, 9¼-inch	114	85	182			Gas	2,500.00	905.00	Domestic; irrigation.	†50		
878	Mr. Mardin	do	C-12	?1884	Bored, 7-inch	115	85	110	32		Hand			Not used			

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
879	John Johnson	Los Coyotes	C-12	1900	Driven, 1¼-inch	114	.....	30	102	....	Hand	.....	.....	Domestic	.....
880	M. O. Kellogg	.....do	C-13	1875	Bored, 7-inch	112	82	168	34	....	Wind	.....	.....	.....do	.....
881	M. H. Cheeseman	.....do	C-13	1903	.....do	109	83	110	45	....	.....do	$105.00	.....	.....do	.....
882	Mrs. Johnson	.....do	C-13	?1899	Hydraulic, 2-inch	110	83	.....	33	....	.....do	.....	.....	.....do	.....
883	C. Raab Creamery Co.	.....do	C-13	?1897	Bored, 2-inch	112	.....	78	....	....	Steam	.....	.....	.....do	.....
884	A. S Escalle	.....do	C-13	.....	Hydraulic, 1¼-inch.	112	.....	90	74	....	Wind	.....	.....	.....do	.....
885	Charles Finch	.....do	C-13	.....	Driven, 1¼-inch	112	86	37	63	....	Hand	.....	.....	.....do	.....
886	Ben Johnson	.....do	C-13	?1900	.....do	115	88	36	106	....	.....do	.....	.....	.....do	.....
887	Julius Baling	.....do	C-13	1898	Bored, 7-inch	111	85	92	....	....	Wind	.....	.....	.....do	.....
888	.....do	.....do	C-13	1891	Driven, 1¼-inch	109	.....	46	63	....	.....do	.....	.....	.....do	.....
889	Henry Schultz	.....do	C-13	1898	Bored, 7-inch	106	82	94	39	....	.....do	93.00	.....	Domestic; irrigation.	.....
890	.....do	.....do	C-13	1892	Driven, 1¼-inch	104	.....	32	45	....	Hand	.....	.....	Domestic	.....
891	A. C. Bertram	.....do	C-13	1900	.....do	102	.....	22	56	....	.....do	.....	.....	.....do	.....
892	C. H. Lee	.....do	C-13	?1880	Bored, 7-inch	100	76	200+	29	....	Wind	.....	.....	Domestic; irrigation.	.....
893	W. Bashove	.....do	B-13	.....	Dug, 4-foot diameter.	92	77	16	43	....	Hand	.....	.....	Stock	.....
894	P. A. Stanton	.....do	B-13	1904	Bored, 10-inch	92	76	135	34	....	Gas	251.00	.....	Irrigation	140
895	.....do	.....do	B-13	?1890	Bored, 3-inch	85	.....	128	34	....	Wind	.....	.....	Stock	.....
896	Mrs. Hein	.....do	B-13	1901	Bored, 7-inch	88	73	72	31	....	.....do	.....	.....	.....do	.....
897	Chas. Sparks	.....do	B-13	.....	.....do	90	72	150	33	.....	.....do	.....	.....	.....do	.....
898	T. W. Dean	.....do	B-13	1900	Driven, 1¼-inch	85	.....	30	75	....	Hand	.....	.....	Domestic	.....

899	C. Whalley	do	B-12	1902	Bored, 7-inch	98	79	127	45	Gas			Irrigation		†20
900	A. M. Ball	do	B-12	?1880	do	98	77	100	35	Wind			Domestic; irrigation.		
901	do	do	B-12	1903	do	98	77	125		Gas			Irrigation		†30
902	A. Messersmith	do	C-12	1900	do	104	78	129	35	Wind	200.00		Domestic; irrigation.		
903	E. L. Hein	do	C-12	1901	Bored, 4-inch	106		160	44	do			Domestic		
904	J. B. Pierce	do	B-12	?1884	do	96		96	32	do			do		
905	Magnolia school district.	do	B-12	1903	Bored, 7-inch	85		120	40	do	115.00		do		
906	A. W. Dearden	do	B-13	1903	do	91		176	60	Hand	180.00		do		
907	J. H. Boney	do	B-13	1899	do	85	70	180	40	Gas	200.00	600.00	Domestic; irrigation.		†20
908	A. Baker	do	B-13	1904	do	81	66	159		Not raised					
909	do	do	B-13	1895	Hydraulic, 2-inch	80		290	31	Horsepower	75.00		Domestic; irrigation.		
910	J. W. Martin	do	B-13	?1895	do	75	64	500	30	Wind, hand			do		
910a	do	do	B-13	?1895	do	75	64	225	30	do			do		
911	F. E. Mittlestet	do	A-13	1902	Bored, 7-inch	73		226		Gas	226.00	425.00	Irrigation		†30
912	do	do	A-13	1896	Bored, 2-inch	73		466		Wind	150.00		Domestic		
913	Miles Cox	do	A-13	?1892	Bored, 7-inch	75	65	288	28	Gas			Irrigation		†15
914	J. Seiditz	do	A-13	?1895	Bored, 2-inch	72	63	151	32	Wind			Domestic; stock		
915	J. Heiman	do	A-13	1894	Bored, 7-inch	78		505		Steam			Irrigation		†40
916	John Nichols	do	A-13	?1894	Bored, 2-inch	65		172	31	Hand			Domestic		
917	L. Bressel	do	A-13	1900	Bored, 7-inch	65		171		Gas	178.00	675.00	Irrigation		†50
918	do	do	A-13	1896	Bored, 2-inch	65		273	26	Wind			Domestic		
919	L. Schmidka	do	A-13	1897	do	68		296	28	do	75.00		do		
920	C. W. Cornwall	do	A-13	1904	Bored, 7-inch	70	62	92		Gas	110.00		Irrigation		†35
921	do	do	A-13	1903	Bored, 7-inch (2)	70	62	88		do	200.00		do		
922	do	do	A-13	?1897	Bored, 2-inch	70	64	500		Not raised					
923	do	do	A-13	1897	Bored, 7-inch	70		400	29	Hand			Domestic		
924	G. Dreger	do	A-12	1900	Bored, 2-inch	69	61	107	30	Wind	40.00		do		
925	J. Dreger	do	A-12	1899	Driven, 1¼-inch	70		156		Hand			do		
926	C. W. Brenner	do	A-12	?1892	Bored, 1¼-inch	70	66	200+	31	do			do		
927	Wm. Domris	do	A-12	1896	Bored, 2-inch	72	68	267	30	Wind			do		
928	do	do	A-12	1904	Bored, 7-inch	72	68	121		Not raised	118.00				

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
929	Gus Linberg	Los Coyotes	A-12	1902	Driven, 1¼-inch	68	61	12	43	....	Hand			Domestic; stock	
930	Geo. S. Burrows	do	A-12	.....	Bored, 2-inch	69	63	200	....	....	Not raised				
931	Wm Gebert	do	A-12	1899	Hydraulic, 2-inch	73	.....	500	....	....	do	$175.00			
932	do	do	A-12	1901	Driven, 2-inch	72	.....	15	47	....	Wind			Domestic; stock	
933	C. Remland	do	A-12	1898	Bored, 2-inch	73	68	260	29	....	do	108.00		Domestic	
934	C. Urbigkait	do	A-12	1903	Bored, 7-inch	74	64	108	30	....	do	120.00	$50.00	do	
935	L. W. Rains	do	A-12	1895	Driven, 2-inch	73	.....	12	46	....	do			do	
936	G. T. Collier	do	A-12	?1894	Bored, 7-inch	77	65	480	25	....	Hand, horse-power.			Domestic; irrigation.	
937	Thos McGuire	do	A-12	1904	do	84	69	124	....	....	Not raised	116.00			
938	do	do	A-12	?1893	do	79	66	512	....	....	do				
939	do	do	A-12	1904	do	79	65	122	....	....	do	116.00			
940	Mrs. B. Masters	do	A-12	?1892	Hydraulic, 2-inch	77	.....	125	29	....	Hand			Domestic	
941	do	do	A-12	?1894	Driven, 2-inch	80	.....	30	42	....	Wind			do	
942	M. Schantz	do	A-12	1901	Bored, 7-inch	89	72	116	31	....	Hand			do	
943	J. E. Hart	do	A-12	1899	Bored, 10-inch	87	72	120	29	....	Gas			Irrigation	†25
944	do	do	A-12	1902	Driven, 1¼-inch	81	.....	18	46	....	Wind			Domestic	
945	John Gustarfason	do	A-11	1897	Bored, 7-inch	87	72	125	31	....	do			do	
946	J. O. Brown	do	A-12	.....	Bored, 2-inch	77	.....	325	29	....	do			do	
947	E. B. Foster	do	A-11	1892	Bored, 7-inch	79	70	504	31	....	do	1,000.00		Stock	
948	do	do	A-11	1883	do	79	70	275	....	....	do			Not used	
949	do	do	A-11	?1898	Hydraulic, 2-inch	75	.....	466	32	....	do			Domestic	
950	W. G. Potter	do	A-11	?1878	Bored, 7-inch	73	65	75			Not raised				

955	W. G. Longhoro	do	A-11	[illegible]	Bored, [illegible]											
956	do	do	A-11	?1896	Bored, 2-inch	72	...	255	30	....	Wind	130.00		Domestic		
957	S. Milner	do	A-11	1899	do	71	...	450	32	....	do	135.00		Domestic; irrigation.		
958	Malcolm Bros	do	A-11	1899	Bored, 8-inch	84	68	263	31	....	Gas			Irrigation		†25
959	do	do	A-11	.....	Hydraulic, 2-inch	84	...	300+	31	....	Wind			Domestic		
960	C. C. Butterfield	do	A-11	?1895	Bored, 2-inch	88	...	295	33	....	do			Domestic; stock		
961	do	do	B-11	1904	Bored, 12-inch	92	75	502	34	....	Gas	1,400.00		Irrigation		
962	Wm. Porter	do	B-12	1900	Bored, 7-inch	92	72	94	43	....	Wind			do		
963	P. Hussey	do	B-12	1903	do	95	....	106	33	....	do	110.00		Domestic		
964	Wm. A. Green	do	B-12	1902	do	95	76	140	....	....	Gas	150.00	650.00	Irrigation		†11
965	do	do	B-12	1903	do	95	76	98	....	....	do	92.00		do		†23
966	Wm. Porter	do	B-12	.....	Bored, 4-inch	90	73	37	....	....	Wind			Domestic; stock		
967	T. Thowson	do	B-12	1898	Driven, 1¼-inch	88	....	16	57	....	Hand			Domestic		
968	J. B. Crayne	do	B-12	1901	Bored, 7-inch	91	78	106	37	....	Wind			do		
969	Mrs. J. B. Cameron	do	B-12	1902	do	96	75	123	....	....	Gas	166.00		Irrigation		†25
970	do	do	B-12	1901	Bored, 4-inch	96	76	96	32	....	Wind			Domestic; stock		
971	L. Harling	do	B-12	1903	do	101	...	92	28	....	do	58.90		Domestic		
972	H. Hodle	do	B-12	1903	Bored, 7-inch	100	78	109	32	....	Hand			do		
973	Geo. Lenz	do	B, C-12	?1899	do	105	82	90	33	....	Wind	80.00		Domestic; irrigation.		
974	A. Steinke	do	B-12	1901	Bored, 4-inch	106	82	95	31	....	do			Domestic		
975	E. D. Murphy	do	C-12	1903	do	106	82	89	40	....	Hand	69.00		Domestic; stock		
976	R. C. Hein	do	C-12	?1891	Bored, 7-inch	108	84	102	54	....	Wind			do		
977	P. A. Peterson	do	C-12	1903	Bored, 10-inch	108	80	112	....	....	Not installed	211.80				
977a	do	do	C-12	1903	do	108	80	118	....	....	do	224.20				
978	J. Hedges	do	C-11	1903	Bored, 7-inch	112	84	104	55	....	Gas	90.40		Irrigation		†25
979	do	do	C-11	1903	do	112	84	104	....	....	do	90.40		do		
980	do	do	C-11	1899	Bored, 4-inch	110	84	70	33	....	Wind			Domestic		
981	J. A. Simpson	do	B-11	1904	Bored, 7-inch	108	83	103	32	....	Gas	85.00		Irrigation		†17
982	do	do	B-11	1903	Bored, 4-inch	108	83	94	32	....	Wind	80.00		Domestic		
983	do	do	B-11	1899	Bored, 7-inch	110	82	130	35	....	do	133.00		Irrigation		

Wells in the Anaheim quadrangle—Continued.

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						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
984	C. W. Amy	Los Coyotes	B-11	?1890	Bored, 4-inch	103	84	65	31		Wind			Domestic	
985	M. C. Morgan	do	B-11	?1900	Hydraulic, 5-inch	101	80	175			Gas			Irrigation	† 18
986	do	do	B-11	?1900	Hydraulic, 6-inch (2)	101	80	80	33		do			do	
987	Mr. Spomg	do	B-11		Hydraulic, 2-inch	98		80	31		Hand			Domestic	
988	Mr. Humerlich	do	B-11		Driven, 1¼-inch	98		30	35		do			do	
989	S. Krueger	do	B-11	?1900	do	98		51	36		do			Domestic; stock	
990	Ed Kelley	do	B-11	?1894	Bored, 2-inch	100		68	35		Wind			do	
991	A. Humerlich	do	A, B-11	1892	Driven, 1¼-inch	90		30	35		Hand			do	
992	A. L. Glass	do	A-11	1901	Bored, 7-inch	87	70	408			Gas			Irrigation	† 40
993	do	do	A-11	?1896	Bored, 2-inch	87		413	33		Wind			Domestic	
994	P. A. Stanton	do	B-11	?1903	Bored, 7-inch	108	89	72	56		do			Domestic; irrigation.	
995	Brookhurst Ranch	do	C-11	?1887	do	13	87	169	31		do			Domestic; stock	
996	P. A. Stanton	do	C-11	1901	do	116	87	18	35		do			do	
997	do	do	C-11	1904	Bored, 10-inch	118	83	375			Gas	$550.00	$1,500.00	Irrigation	† 100
998	do	do	C-11	1898	Bored, 7-inch	118	90	99			do	228.85		do	† 40
998a	do	do	C-11	1898	do	118	90	225			do			do	
999	N. M. Barron	do	C-11	1903	do	114	86	140	43		Hand			Domestic; stock	
1000	Chas. Allgeyer	do	C-11	1904	do	114	92	94			Wind	94.00	45.00	do	
1001	F. H P. Miller	do	C-11	1903	do	119	93	64	33		do	76.00	+275.00	Domestic; irrigation.	
1002	D. A. Browning	do	C-11	1888	do	122	92	75	35		do	78.00		Domestic; stock	

					53 feet.											
1004	O. L. Matthew	do	D-11	1896	Bored, 2-inch	124		375	29		do			Domestic		
1005	G. H. Hatfield	do	D-11	1892	Bored, 7-inch	128	95	95	35		Gas	95.00	825.00	Domestic; irrigation.	†35	
1006	do	do	D-11	1903	do	128	95	131	35		do	125.00		Irrigation		
1007	Mrs. C. C. Browning	do	D-11	1879	do	132		375	28		Not installed			Domestic; stock		
1008	do	do	D-11	1904	do	132	94	205	47		Electric motor	220.50		Irrigation		
1009	do	do	D-11	1904	do	132	94	105			Not installed	92.35		do		
1010	do	do	D-11	1904	do	132	94	105			do	92.35		do		
1011	J. G. Welch	San Juan Cajon	D-11	1904	Bored, 4-inch	136	94	95	33		Hand	85.00		Domestic		
1012	W. C. Heyman	do	D-11	?1897	do	130		80	31		Wind			Domestic; stock		
1013	E. Bushnell	Los Coyotes	D-11	?1898	Bored, 2-inch	126		75	42		do			Domestic		
1014	W. F. Sonneman	San Juan Cajon	D-11	?1897	do	127		80	39		do			do		
1015	H. Requarth	Los Coyotes	D-11	1902	Bored, 7-inch	126	90	80	42		Gas			Irrigation	†25	
1016	Mrs. Reardon	do	C-12	1900	Bored, 9¼-inch	116		246			do			do	†45	
1017	do	do	C-12		Driven, 1¼-inch	115			60		Hand			Domestic		
1018	E. Henry	do	C-12	1902	Bored, 4-inch	113	87	79	35		Wind	60.00		do		
1019	A. C. Spalding	do	C-12	1903	Bored, 7-inch	116	88	77	37		Hand	75.90		Domestic; stock		
1020	Truman Campbell	do	C-12	?1901	Bored, 9¼-inch	118	89	182	31		Gas	250.00	625.00	Irrigation; domestic.	†48	
1021	A. Henry	do	C-12	1901	Bored, 6-inch	118	89	75	42		Hand	65.00		Domestic		
1022	M. M. Poole	do	C-12	1899	Bored, 7-inch	119	90	82	57		do			do		
1023	A. N. Henry	do	C-12	1870	do	120	89	320			Wind			do		
1024	do	do	C-12	1898	do	122	89	225			Gas	500.00		Irrigation	†75	
1025	do	do	C-12	1897	do	122	89	600			do			do		
1026	Chas. W. Spooner	do	C-12		do	120	89	77	53		Hand			Domestic		
1027	W. E. Morsch	do	D-12		do	120	89	78	56		do			do		
1028	Fred Stankey	do	D-12	1902	Bored, 4-inch	122	81	78	58		Wind			do		
1029	Lewis Gleichner	do	D-12	1902	Bored, 7-inch	123		137	57		do	130.00		do		
1030	John Huhn	do	D-12	1899	Driven, 1¼-inch	125		40	66		Hand			Domestic; stock		
1031	F. H. Wessler	San Juan Cajon	D-12	1901	Bored, 3-inch	126		77	83		do	79.00		Domestic		
1032	V. Montgomery	do	D-12		do	126		78	42		do			do		
1033	B. J. Snodgrass	do	D-12	1902	Driven, 2-inch	127		47	78		do			do		
1034	D. Stark	do	D-12	?1898	Bored, 9¼-inch	127		160	38		Wind			Domestic; irrigation.		

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
1035	G. Meger	San Juan Cajon	D-12		Bored, 7-inch	125	89	101	34	....	Wind			Domestic; stock	
1036	J. Newman	do	D-12	1903	Bored, 4-inch	125	.....	120	48	....	Hand	$98.00		Domestic	
1037	J. W. Duckworth	do	D-12	1898	Bored, 4-inch, 60 feet; 2-inch, 44 feet.	125	85	104	44	....	Wind			do	
1038	Loara district school	do	D-12	1902	Bored, 4-inch	129	.....	100	38	....	do			do	
1039	L. Bolz	do	D-12	1902	do	130	.....	75	44	....	do			do	
1040	G. Betts	do	D-12	1902	Driven, 1¼-inch	130	.....	40	63	....	Hand			do	
1041	G. Grenke	do	D-12	1903	Bored, 4-inch	126	85	132	43	....	do			do	
1042	Jacob Rinker	do	D-12	?1899	Hydraulic, 2-inch	133	.....	108	45	....	do			do	
1043	F. Dettner	do	D-12		Bored, 7-inch	134	92	126	39	....	Wind			do	
1044	F. Henderson	do	D-12	1882	Hydraulic, 2-inch	133	.....	55	57	....	Hand			do	
1045	H. Williams	do	D-12	1903	Driven, 1¼-inch	134	.....	40	49	....	Wind			do	
1046	Mrs. S. Rees	do	D-12	1900	Bored, 3-inch	134	.....	89	50	....	do			do	
1047	T. J. F. Boege	do	D-12	1886	Bored, 7-inch	136	96	92	....	....	do			do	
1048	do	do	D-12	1902	do	136	96	88	40	.....	Gas	75.20	$300.00	do	
1049	Mr. Spencer	do	D-12		do	137	95	80	20	....	Hand			do	
1050	Union Brewing Co	do	D-12	?1890	do	136	96	86	40	....	Steam			do	
1051	C. Bennerscheidt	do	D-12	1884	do	133	93	88	42	....	Hand			do	
1052	John Shaw	do	D-12	1900	do	129	.....	103	43	....	Gas			Domestic; irrigation.	†30
1052a	do	do	D-12	1901	do	129	.....	103	43	.....	do			Irrigation	
1053	C. W. Marden	do	D-12	1903	Bored, 10-inch	128	91	125	....	....	Not installed				

1054	.....do	.....do	D-12	?1900	Bored, 7-inch	128	89	98	41		Wind	100.00		Domestic		
1055	Tim Carroll	.....do	D-12	?1880	.....do	130		115	37		Horsepower			Irrigation		
1056	Chas. Lange	.....do	D-12	1877	.....do	132	93	84	40		Wind			Domestic		
1057	Mrs. Fay	.....do	E-12	?1893	Bored, 8-inch	138	95	81	38		.....do			Domestic; irrigation.		
1058	.....do	.....do	E-12	1894	Bored, 7-inch	138		90			Gas			Irrigation		
1059	F. A. Korn	.....do	E-12	?1874	.....do	138	94	98			Hand			Domestic		
1060	F. A. Maurer	.....do	E-12	1880	.....do	138		95	43		Wind			.....do		
1061	W. H. Hunt	.....do	E-12	?1897	Driven, 1¼-inch	139		63	47		Hand			.....do		
1062	F. Mickle	.....do	D-12	1900	Bored, 7-inch	137	90	125	44		Wind	117.00		.....do		
1064	N. A. Bittner	.....do	D-12	?1896	Bored, 3-inch	138		79	40		.....do	45.00	45.00	.....do		
1065	Mrs. Felber	.....do	D-12	1899	Bored, 4-inch, 25 feet; 2-inch, 55 feet.	139		80	45		Hand			.....do		
1066	J. Everhardy	.....do	D-12	?1884	Bored, 7-inch	140		90	49		Wind			Domestic; irrigation.		
1067	F. A. Korn	.....do	D-12	?1880	.....do	140	94	87	49		Horsepower			.....do		
1068	W. G. Krutz	.....do	D-12	?1885	.....do	139	94	57	52		Wind			Domestic		
1069	W. A. Wallace	.....do	D-12	?1899	Bored, 4-inch	137		96	59		Gas			Domestic; irrigation.		
1070	J. McCorkindale	.....do	D-12	1903	Bored, 7-inch	136	97	99	49		.....do			Irrigation		†68
1070a	.....do	.....do	D-12	1901	.....do	136	97	99	49		.....do			.....do		
1071	.....do	.....do	D-12		Bored, 4-inch	136		80	61		Wind			Domestic		
1072	Chas. Eells	.....do	D-12	?1899	Bored, 7-inch	132	93	140	50		.....do			.....do		
1073	H. D. Young	.....do	D-12	1903	.....do	132	94	80	58		.....do			.....do		
1074	P. Boons	.....do	D-12	?1894	Driven, 1¼-inch	130		35	80		Hand			Domestic; stock		
1075	F. W. Fleischman	.....do	D-11, 12	1902	Bored, 7-inch	134		84	31		Gas			Domestic		13
1076	W. I. Carver	.....do	D-11	1903	.....do	140	98	79	38		Wind			.....do		
1077	.....do	.....do	D-11	?1903	.....do	142	98	79	39		Hand			.....do		
1078	.....do	.....do	E-11	1901	.....do	145	101	75			Gas			Irrigation		†22
1079	.....do	.....do	E-11	1901	Bored, 10-inch	145	101	86			.....do			.....do		
1080	Mrs. A. Frohling	.....do	E-12	1903	Bored, 3-inch	144		105	54		Wind	100.00		Domestic		
1081	A. Bittner	.....do	E-12	?1902	Bored, 7-inch	143	94	144			Gas			Irrigation		†75
1082	.....do	.....do	E-12	?1902	.....do	143	94	144			.....do			.....do		
1083	.....do	.....do	E-12	?1880	.....do	140	92	81	44		Wind			Domestic		
1084	J. L. Shumacher	.....do	E-12	?1899	.....do	139	93	90	45		.....do	77.00		.....do		

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 1,000,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
1085	A. B. Markle	San Juan Cajon	E-12		Bored, 7-inch	139	93	81	40		Gas			Domestic; irrigation.	
1086	J. A Tyler	do	E-12		do	145	105	73	40		Wind			Domestic	
1087	G. Baumgart	do	E-12	1903	do	143	95	100	46		Gas	$91.00	$225.00	Domestic; irrigation.	
1088	Orphans Home	do	E-12		do	145	96	95	43		Wind			Domestic	
1089	C. O. Rust	do	E-12	1874	do	148	96	92	37		do			do	
1090	do	do	E-12	?1899	do	148	96	100	37		Gas	100.00		do	
1091	M. C. Langenberger	do	E-12	?1869	do	152	96	95	37		do			do	
1092	J. J. Snyder	do	E-11	?1863	do	148	99	69	37		Wind			do	
1093	J. A Eymann	do	E-11	?1865	do	148	99	80	35		do			do	
1094	Mrs. F. Dyer	do	E-11	1881	do	153	103	70	38		do			do	
1095	do	do	E-11	1903	do	153	104	110			Gas	101.00		Irrigation	†95
1096	do	do	E-11	1903	do	153	104	119			do	110.40		do	
1097	Mrs. N. G. Perry	do	E-11	1900	Bored, 4-inch	153		84	39		Wind	47.45	40.00	Domestic	
1098	A. R. Eddis	do	E-11	?1899	Bored, 3-inch	154		85	35		do			do	
1099	H. Wilke	do	E-11	1899	Bored, 7-inch	154	99	95	39		do			do	
1100	Mrs. J. Stoodtholl	do	E-11	?1870	do	154	103	90	37		do			Domestic; irrigation.	
1101	A. Backs	do	E-12		do	152	98		32		do			Domestic	
1102	Anaheim city	do	E-12	1896	Bored, 10-inch	153	99	112	39		Steam			do	
1103	do	do	E-12	1896	do	153	99	116	39		do			do	
1104	do	do	E-12	1896	do	153	99	120	39					do	

1105	Mr. F. Ruhmann	do	E-12		Bored, 7-inch	150	97	90	41	do			do	
1106	W. J. Fisher	do	E-12	?1898	Hydraulic, 2-inch.	150		90		do			do	
1107	Wm. Heying	do	E-12	?1901	Bored, 4-inch	149		88	41	do			do	
1108	H. Hussman	do	E-12	?1870	Bored, 7-inch	150		110	39	do			do	
1109	T. S. Grimshaw	do	E-12	1883	do	149		90	45	do			do	
1110	J. Bennerscheidt	do	E-12	1880	do	149		90	55	do			do	
1111	J. M. Roberts	do	E-12	1895	do	147	96	89	40	do			do	
1112	J. Bennerscheidt	do	E-12	?1884	do	148		90	38	do			do	
1113	M. Nebeling	do	E-12		do	149	96	73	40	do			do	
1114	R. Fossek	do	E-12	?1885	do	149	96	85	44	do			do	
1115	Wm. Konig	do	E-12	?1870	do	152	98	83	45	Horsepower			do	
1116	Colonel Hart	do	E-12		do	153	98	87	40	Wind			do	
1117	F. Bamn	do	E-12	?1888	do	153	99	83	40	do			do	
1118	H. A. Stough	do	E-12	1893	do	150	103	98	41	do			do	
1119	J. B. Rea	do	E-12	?1897	do	154	97	96	39	do			do	
1120	Mr. McWilliams	do	E-12	1892	do	155	100	88	45	do	96.00	40.00	do	
1121	P. J. Mercereau	do	E-12	1901	do	154	99	100	40	Gas			Domestic; irrigation.	
1122	Miss S. M. Zeien	do	E-12		Bored, 4-inch	154		90	34	Wind			Domestic	
1123	A. Rimpau	do	E.F-12	?1883	Bored, 7-inch	157	100	85	44	do			do	
1124	P. Stechert	do	E-12	1888	do	155	99	92	43	do			do	
1125	Mrs. E. Pellegrin	do	E-12		do	154	98	100		do			do	
1126	J. E. Strehle	do	E-12		do	160	101	80	35	Horsepower			Domestic; irrigation.	
1127	E. F. Wyatt	do	E-12	1903	do	161		99	35	Gas	800.00	175.00	do	
1128	A. Becker	do	F-12		Bored, 4-inch	161		75	52	Wind			Domestic.	
1129	A. Bissell	do	F-12		do	165		80	50	do			do	
1130	A. E. Susmil	do	F-12	?1899	do	167		78	53	Gas	69.75	150.00	Domestic; irrigation.	
1131	H. Kreger	do	F-12		Bored, 7-inch	168	101	87	39	Wind			do	
1132	H. Gunderson	do	F-12		do	169		92	38	Hand			Domestic; stock	
1133	L. J. Christopher	do	F-11	1903	do	169	105	90	39	do	92.00		Domestic	
1134	Wm. Kretschmer	do	F-11		do	168		100	40	Wind			do	
1135	J. H. Brunworth	do	F-11	?1889	do	168	103	101	31	do			do	
1136	Mrs. A. D. Adams	do	F-11	1903	do	169		92	35	Hand			do	

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
1137	F. W. Beecroft	San Juan Cajon	F-11	1894	Bored, 7-inch	169	103	103	35		Gas			Domestic; irrigation.	
1138	M. Neblung	do	F-11		do	163	99	137	36		Wind			Domestic	
1139	James Shearer	do	F-11		do	162	99	86	42		do			do	
1140	A. W. Maxwell	do	E-11		Bored, 4-inch	161		90	32		do			do	
1141	do	do	F-11	1902	Bored, 10-inch	163	102	103			Gas	$103.00		Irrigation	†80
1142	do	do	F-11	1902	do	163	102	113			do	113.00		do	
1143	M. A. Smith	do	E-11		Bored, 7-inch	161	105	110	45		Hand			Domestic	
1144	J. E. Allen	do	F-11	1900	Bored, 4-inch	166		74	48		Wind			do	
1145	J. A. Aubert	do	F-11		do	166		96	49		Hand			do	
1146	Joe Roesler	do	F-11	1901	do	165		80	54		do	76.00		do	
1147	John Campbell	do	F-11	1900	Bored, 7-inch	166	103	94	33		Wind			do	
1148	Frank Edison	do	F-11	1896	do	166	102	96	41		do			Domestic; irrigation.	
1149	W. H. Yarger	do	F-11		do	166	102	71	45		do			Domestic	
1150	Mrs. Staley	do	F-11		do	178		86	39		do			do	
1151	W. I. Wilson	do	G-11	1889	do	185	108	83			do			do	
1152	J. B. McFarland	do	G-11		do	188	108	86	35		do			do	
1153	L. Parker	do	G-11		do	185	108	91	41		do			do	
1154	Mrs. Staley	do	F-11	1903	Bored, 10-inch	178	108	103	42		Gas			Irrigation	†85
1155	do	do	F-11	1903	do	178	108	103			do			do	
1156	Thomas Ahern	do	G-11	1904	do	182		119			Not installed				
1156a	do	do	G-11	1904	do	182		127			do				
											do				

1157	E. Tucker	do	H-11		Bored, 7-inch	202	111	99	41		Wind			Domestic	
1158	A. Derksen	do	H-11	1901	Bored, 10-inch	208	114	100	47		do	196.00		do	
1159	Mrs. D. Berdtch	do	H-11	1902	do	199	115	181	46		Hand	300.00		Domestic; stock	
1160	Orange County	do	G-12	1900	Bored, 7-inch	187		106			Gas			Roads	
1161	E. C. Conger	Santa Ana	I-11		do	227	140	142	68		Wind			Domestic	
1162	Passmore ranch	do	I-11	1893	do	245		51	96		do			do	
1163	do	do	I-11	1894	Dug, 3 by 4 foot	230	205	27	61		Hand			Stock	
1164	J. Watson	do	K-11	1903	Dug, 4-foot diameter.	262	193	77			Wind			Domestic	
1165	John Bush	do	K-11	1900	Dug, 3 by 4 foot	250	225	30	75		do			Domestic; stock	
1166	August Lemke	do	K-11	1902	Dug, 3 by 3 foot	249	196	57	48		Hand			do	
1167	Chris Lemke	do	K-11	1897	Dug, 3 by 4 foot	254	230	31	73		do			do	
1168	Mrs. V. Yorba	do	L-11	1903	Bored, 7-inch	300		196	86		Gas			Domestic; irrigation.	
1169	E. W. Pyne	do	M-10		Driven, 1¼-inch	325		25	66		Hand			Domestic	
1170	do	do	M-10		Bored, 4-inch	320	303	46	66		do			do	
1171	Beralta school district.	do	M-10	1900	Bored, 2-inch	315		100	51		Wind			do	
1172	J. Bullied	do	M-10		Dug, 3½ by 3½ foot	320	305	17	54		Hand			Domestic; stock	
1173	R. Cooper	do	N-10	1886	Dug, 3 by 3 foot	325	304	23	65		do			Domestic	
1174	Mrs. H. Bedoma	Canyon de Santa Ana.	M-10	?1877	Bored, 7-inch	275	222	62	65		Wind			Domestic; stock	
1175	D. M. Towne	do	M-10		Bored, 4-inch	263	Dry.	51			do			Domestic	
1176	Yorba school district.	do	L-10	?1899	do	267		68	61		do			Not used	
1177	Mrs. Yorba	do	L-9		Bored, 7-inch	270		49			do			Domestic	
1178	Geo. G. Bayha	do	L-10	1903	do	260	208	64	61		Gas			do	
1179	W. R. Carpenter	San Juan Cajon	H-10	1899	do	225	111	120	44		Hand	225.00		do	
1180	Beng. Kraemer	do	H-10	1900	do	220	115	146	38		Wind			do	
1181	E. M. Kraemer	do	H-10	1886	do	205	115	129			Not raised				
1182	do	do	H-10	1902	Bored, 10-inch	205	115	160	40		Gas			Irrigation	51
1183	Joseph Baxter	do	H-10	1904	do	198	110	187			do	400.00	$1,950.00	do	
1184	Wm. Crotther	do	H-10	1890	Bored, 6-inch	196	111	109	50		Wind			Domestic	
1185	Placentia school district.	do	H-9	1903	Bored, 7-inch	220		255	65		do			do	
1186	P. Hansen	do	H-9	?1878	do	225	136	130	67		do			do	
1187	Wesley Almes	do	H-9	1903	do	225	130	151	61		Hand	150.00		do	
1188	Joseph East	do	H-9	1894	Bored, 6-inch	245	161	124	83		Wind			do	

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
1189	Saml. Kraemer	San Juan Cajon	H-9	1902	Bored, 7-inch	270	119	200	73		Wind	$310.00	$65.00	Domestic	
1190	Mr. Mesmer	do	I-9		do	283	200	139	57		do			do	
1191	W. B. Hervey	do	H-9		do	280	130	325	83		do			do	
1192	R. J. Laidlaw	do	I-9	?1897	Bored, 6-inch	310	222	275	71		do			Domestic; irrigation.	
1193	Jas. Stafford	Olinda	I-9	?1897	Bored, 7-inch	285	200	105	95		do			Domestic	
1194	J. W. Newell	do	J-9	?1896	do	312	245	180	90		do			Domestic; irrigation.	
1195	Santa Fe Oil Co	do	J-8	1900	Bored, 10-inch	350	260	360	66		Steam			Oil wells	
1196	do	do	J-8	1901	do	350		260	45		do			do	
1197	do	do	J-8	1902	do	350		200	42		do			do	
1198	do	do	J-8	1903	do	350	260	195	38		do			do	
1199	Iowa Oil Co	do	J-7	1902	Bored, 7-inch	378	258	200	73		do			Oil well	
1200	F. R. Holcome	San Juan Cajon	D-10	1890	Bored, 4-inch	132		69	71		Wind			Domestic; irrigation.	
1201	J. A. Vail	do	D-10	1892	do	130	107	76	48		do			do	
1202	J. Widdmer	do	D-9		Bored, 7-inch	135		175	55		do			Domestic	
1203	Mrs. A. Stone	do	E-10	1896	do	147	116	83	55		do			Domestic; irrigation.	
1204	Jacob Wintter	do	E-10	1882	Bored, 6-inch	143		146	37		do			Domestic	
1205	W. A. Barnes	do	E-10	1903	Bored, 7-inch	147	107	138	36		Hand	131.00		do	
1206	S. N. Fuller	do	D-10	1902	do	147	115	200+	42		Wind			do	
1207	E. Stone	do	D-10	1901	do	148	115	142	44		do			do	
1208	B. F. Porter	do	D-10	1892	do	136		95	50		do			do	

1209	Geo. F. Miles	do	E-11	1903	Bored, 10-inch	152	96	256			Gas	$1,000.00		Irrigation	†35
1210	do	do	D-11	1901	Hydraulic, 4-inch	145	103	114	29		Wind			Domestic	
1211	G. D. Houston	do	D-11		Bored, 4-inch	130	94	80	33		do			do	
1212	W. Ruderick	do	D-10		Bored, 7-inch	126	96	117	32		do			do	
1213	A. B. Johnson	do	D-10	1899	Bored, 4-inch	127	103	83	39		do			do	
1214	A. Goodwin	do	D-10	1884	Bored, 7-inch	127	102	350	38		do			do	
1215	J. H. Clever	do	D-9, 10	1899	do	147	102	181			Gas	*1,500.00		Irrigation	22
1216	do	do	D-9, 10	1891	Bored, 4-inch	145	100	68	66		Hand			Domestic	
1217	M. V. B. Lovering	Los Coyotes	D-10	1883	Bored, 7-inch	127	96	141	35		Wind			do	
1218	Alex. Gardner	do	D-10	1899	Hydraulic, 4-inch	125	104	167	30		Gas			do	
1219	W. H. Routzahn	do	D-10		Bored, 7-inch	124	91	200+	33		Wind			do	
1220	P. A. Nicholas	San Juan Cajon	D-10	?1888	do	132			42		Gas			Domestic; irrigation.	
1221	O. M. Skinner	Los Coyotes	C-10	1893	do	121	92	196	42		Wind	300.00		Domestic	
1222	Wm. Schulte	do	C-10	1876	do	119	92	135	38		do			do	
1223	M. A. Spencer	do	C-10	1892	do	119	91	136	42		do	160.00		do	
1224	I. A. Christlieb	do	C-10	1898	do	118	93	198	40		do			do	
1225	Smith Rancho Co	do	C-10	1882	do	112	89	354	37		do			do	
1226	do	do	C-10	1885	do	112	89	581			Not raised				
1227	S. A. Bedell	do	C-10	1876	do	112	89	361	51		do				
1228	do	do	C-10	1904	Bored, 10-inch	112	89	365	65		Gas	850.00	1,000.00	Irrigation	†50
1229	Dean & Braly	San Juan Cajon	E-9	1898	Bored, 4-inch	155		145	55		Wind			Domestic	
1230	M. Cookson	Los Coyotes	B-10	?1892	Bored, 7-inch	86	76	235			Gas			Irrigation	
1231	do	do	B-10		do	86	76	267			do		2,000.00	do	†135
1232	do	do	B-10		do	86	76	278			do			do	
1233	do	do	B-10		do	87	76	240	39		Hand			Domestic; stock	
1234	J. W. Watson	do	A-9	?1882	do	75	75	175			Gas, artesian			Irrigation	†50
1235	do	do	A-9		do	75	75	175			do			do	
1236	do	do	A-10	?1882	do	75	75	200+	34		Artesian			Not used	
1237	do	do	A-10		Hydraulic, 3-inch	74	74	265	33		Wind			Domestic	
1238	Gus Hansen	do	B-10	1899	Bored, 7-inch	103	92	295			Not raised				
1239	do	do	B-10	1902	Bored, 10-inch	103	95	518			Gas	*2,200.00		Irrigation	37
1240	do	do	B-10	1894	Hydraulic, 2-inch	103	92	280	33		Wind			Stock	
1241	do	do	B-10	1900	Hydraulic, 3-inch	102	91	170	35		do			Domestic	
1242	Mr. Leonard	do	A-10	?1882	Hydraulic, 2-inch	78	72	200+	29		Hand			do	

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
1243	J. Jones	Los Coyotes	A-10	1895	Bored, 6-inch	74	72	359	28	....	Hand	$600.00	.....	Domestic	.....
1244	J. H. Wright	....do	A-10	1893	Bored, 4-inch	71	72	.....	33	....	....do	.....	.....	....do	.....
1245	Pacific Creamery Co.	....do	A-10	1892	Bored, 7-inch	76	72	340	28	65	Steam	.....	.....	....do	.....
1246	Geo. Wilcox	....do	A-10	1892	....do	76	72	190	31	65	Not raised	.....	.....	.....	.....
1247	I. D. Jaynes	....do	A-10	.....	Bored, 6-inch	77	73	150	.....	....	Gas	.....	.....	Irrigation	†40
1248	....do	....do	A-10	1890	Bored, 4-inch	76	72	137	34	65	Hand	.....	.....	Domestic	.....
1249	Los Lomas Rancho	....do	B-9	?1898	Bored, 10-inch	95	92	1,000	.....	....	Not raised	.....	.....	.....	.....
1250	....do	....do	A-8	?1898	....do	140	140	450	30	66	Artesian	.....	.....	Domestic; irrigation.	†15
1251	....do	....do	A-8	.....	....do	140	140	450	30	66	....do	.....	.....	....do	†3
1252	....do	....do	A-8	.....	....do	141	140	450	.....	....	Not raised	.....	.....	.....	.....
1253	J. T. Coleman	....do	A-10	.....	Bored, 7-inch	72	68	200+	42	....	Gas	.....	$500.00	Irrigation	†40
1254	....do	....do	A-10	.....	....do	72	68	100	.....	....	Not raised	.....	.....	.....	.....
1255	Geo. H. Warren	....do	.....	1902	Hydraulic, 2-inch	75	71	365	56	....	Wind	.....	.....	Domestic	.....
1256	R. A. Sailor	....do	A-10	1891	Bored, 7-inch	74	71	200+	25	66	Horse power	.....	.....	Domestic; irrigation.	.....
1257	J. E. Millikin	....do	A-11	1894	Hydraulic, 2-inch	74	69	200	28	65	Gas	.....	.....	....do	.....
1258	J. Yohn	....do	A-11	.....	....do	74	66	150	.....	....	Wind	.....	.....	Irrigation	.....
1259	....do	....do	A-11	.....	....do	74	66	135	35	....	....do	.....	.....	Domestic	.....
1260	Wm. Goldie	....do	A-11	1902	....do	87	79	75	34	....	....do	.....	.....	....do	.....
1261	J. Kee	....do	A-11	?1882	....do	87	79	400+	35	....	....do	.....	.....	....do	.....
1262	E. D. Hiserodt	....do	C-10	1900	Hydraulic, 3-inch	123	100	80	33	65	....do	50.00	.....	....do	.....
1263	A. H. Gale	....do	C-11	1902	....do	124	.....	60	39	.....	do	.....	.....	....do	.....

		....do	C-11		Driven, 1¼-inch	123										
1265	J. A. Clark	....do	C-11	1904	Bored, 12-inch	123	94	350			Not raised	738.65				
1266	....do	....do	C-11	1901	Hydraulic, 3-inch	24	100	87	32		Wind			Domestic		
1267	J. Schneider	....do	C-10	1896	....do	123	105	86	35		....do			....do		
1268	S. K. Hollman	....do	C-11	1894	Bored, 7-inch	115	91	180	31		....do			....do		
1269	A. E. Sprague	....do	B-11	1890	....do	105	87	200+	34		Gas			Irrigation		† 25
1270	....do	....do	B-11	1900	Bored, 10-inch	105	87	200+	34		....do			....do		
1271	W. D. Smith	....do	B-10	1897	Hydraulic, 3-inch	92	83	200	33		Wind			Domestic; irrigation.		
1272	I. R. Williams	....do	B-11	1895	Bored, 4-inch	97	85	90	28		....do			Domestic		
1273	....do	....do	B-11	1876	Bored, 7-inch	98	85	200			Not raised					
1274	W. S. Young	....do	A-11	1901	Hydraulic, 4-inch	83	73	110	29	66	Hand			Domestic		
1275	....do	....do	A-11	1894	Hydraulic, 2-inch	83		412			Not raised					
1276	J. H. Bouvesrue	....do	B-10	1898	Bored, 7-inch	90	79	212			Gas			Irrigation		† 35
1277	....do	....do	B-10	1892	Hydraulic, 3-inch	90	79	212			....do			....do		
1278	H. H. Howell	....do	A-10		Bored, 7-inch	84	76	400+			....do			....do		† 25
1279	....do	....do	A-10		Driven, 1¼-inch	84	76	14	39		Hand			Domestic		
1280	Columbia Commercial Company.	....do	D-9	1903	Bored, 7-inch	127	89	180			Gas			Irrigation		16
1281	....do	....do	D-9	1904	....do	127	89	160			....do			....do		11
1282	Mrs. S. Rorden	San Juan Cajon	E-10	1884	....do	150	114	166	49		Wind			Domestic		
1283	H. Burdorf	....do	E-10	?1882	....do	154	114	200+	37		....do			....do		
1284	....do	....do	E-10	1904	....do	160	109	132			Gas			Irrigation		
1285	....do	....do	E-10	1903	Bored, 10-inch	160	109	382			....do			....do		
1286	R. F. Parker	....do	E-10	1899	Hydraulic, 3-inch	162	110	125	34		Wind			Domestic		
1287	A. Miller	....do	E-10	?1882	Bored, 7-inch	153	110	82	34		....do			....do		
1288	Ed Sell	....do	E-10	1899	Hydraulic, 3-inch	170	13	115	35		....do			....do		
1289	....do	....do	E-10	1902	Bored, 8-inch	169	13	160			Gas		800.00	Irrigation		
1290	A. Wright	....do	F-10	1892	Bored, 7-inch	170	106	121	46		Wind			Domestic		
1291	W. A. Goodwin	....do	F-10	1903	Bored, 6-inch	173	103	120	35		Hand			....do		
1292	J. B. Harlow	....do	F-10	1900	Hydraulic, 4-inch	174	105	96	45	65	....do			....do		
1293	B. Schumacher	....do	F-10	1885	Bored, 7-inch	176	12	113	62	65	....do			....do		
1294	A. L. Michaeli	....do	F-10		....do	178	110	98	48	65	....do			....do		
1295	A. Porter	....do	F-10	1903	....do	178	108	114	40		Wind			....do		
1296	Mrs. M. Selinger	....do	G-10	1885	....do	181	110	100	53		....do			....do		

GEOLOGY DEPARTMENT

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
1297	A. Duffill	San Juan Cajon	G-10		Bored, 7-inch	195	108	202	49		Wind			Domestic	
1298	E. Krentz	do	F-10	1902	Hydraulic, 4-inch	169	103	93	34	65	Hand			do	
1299	W. B. Houston	do	F-10	1903	do	173	108	109	64	66	do			do	
1300	A. B. Annin	do	E-9, 10	1897	Hydraulic, 3-inch	170	128	142	49		Wind			do	
1301	T. J. McCart	do	E-9	1891	Bored, 10-inch	200	114	140	51		Gas			do	1½
1302	L. B. Benchley	do	E-9	1899	Bored, 7-inch	235	100	305			do	*$1,000.00		Domestic; irrigation.	6
1303	J. C. Sheppard	do	E-9	1891	do	173		107	73		Wind, gas			Domestic	
1304	Stearn & Goodman	do	E-9	1901	Hydraulic, 4-inch	173		100	48		Hand			Domestic; stock	
1305	H. W. Krug	do	F-9	1904	Bored, 10-inch	180	119	126			Gas			Irrigation	
1306	A. Block	do	F-9	1900	Hydraulic, 4-inch	184	112	124	102		Wind			Domestic	
1307	Touwsau Bros	do	E-9	1903	Bored, 10-inch, 230 feet; 7-inch, 70 feet.	235	100	300	48		Gas			Domestic; irrigation; stock.	
1308	do	do	E-9	1902	Bored, 7-inch	250	09	232			Not raised				
1309	J. C. Rogers	do	F-9	1899	Hydraulic, 3-inch	192		160	68		Hand			Domestic	
1310	O. des Granges	do	F-9	1900	Bored, 7-inch	198	113	183	51		Wind			do	
1310a	J. des Granges	do	G-9	1904	do	205		166			Hand			do	
1311	C. S. Knowlton	do	F-9	1884	do	192	110	123	72		do			do	
1312	J. J. Hunter	do	F-10	1882	do	165	103	125	48		Wind			Domestic; irrigation.	

1316	F. X. Dauser	do	G-10	1903	Bored, 12-inch	200	104	262		Gas				Irrigation	†35
1317	do	do	G-10	1896	Bored, 7-inch	199	105	108	76	Wind				Domestic	
1318	S. S. Twombly	do	F-9	1890	do	194	74	150	76	do				do	
1319	Mrs. Mattie Hansen	do	G-9	1883	do	207	106	115	88	do				do	
1320	Mrs. Tombes	do	G-9	1902	do	252	170	165		do				do	
1321	A. T. Pendleton	do	G-8	1900	do	267	173	187	107	do	222.50			Domestic; irrigation.	
1322	F. J. McFadden	do	G-8	1902	do	267		188	97	do				Domestic	
1323	J. R. Hinde	do	G-8	1876	Bored, 12-inch	283	188	113	94	do				do	
1324	J. K. Tuffree	do	H-8	?1878	Bored, 7-inch	284		190	49	Gas				Domestic; irrigation.	
1325	Jas. J. Ortega	do	H-8	?1888	do	182		200+	91	do				Domestic	
1326	J. N. Nenno	do	H-7	1903	Bored, 10-inch	365	232	550	62	do	1,500.00	$875.00		Domestic; irrigation.	
1327	Wm. Key estate	do	G-8	1900	Bored, 10-inch, reduced to 7-inch, reduced to 2-inch.	300	167	700	56	do				Domestic; stock	
1328	Thos. Strain	do	G-8	1901	Bored, 8-inch	322	132	329	54	do	545.00	1,300.00		Domestic; irrigation.	
1329	E. K. Clokke	do	G-8	1892	Bored, 3-inch	270		150	83	Wind				Domestic	
1330	F. B. Dunham	do	G-8	?1887	Bored, 7-inch	235	173	123	73	do				do	
1331	D. Hetchbrink	do	G-9	1901	Bored, 4-inch	235		153	88	do	154.00	55.00		do	
1332	Henry Hetchbrink	do	G-9	1886	Bored, 7-inch	248	158	130	86	do				do	
1333	W. F. Coulter	do	G-9	1899	Bored, 4-inch	223	127	130	96	do				do	
1334	E. Utt	do	F-6	?1899	Bored, 7-inch	380	313	97	57	do				Domestic; stock	
1335	E. Ford	do	F-6		do	364	306	100	102	do				Domestic	
1336	do	do	F-6	1903	Bored, 10-inch	372		185		Gas				Irrigation	5
1337	E. Utt	do	F-6	1904	Bored, 7-inch	375	302	320		do	800.00	700.00		do	
1338	Mr. Green	do	E-6		Dug, 3 by 3 foot	320	295	27	57	Hand				Domestic	
1339	S. W. Baldwin	do	E-5	1901	Bored, 8-inch	356	261	199	68	Gas	253.50	947.00		Irrigation	†10
1340	G. W. King	do	E-6	1901	Bored; 10-inch	315	278	345	52	do				do	†30
1341	M. C. Dodge	do	E-5	1898	Bored, 7-inch	352	260	160	70	Wind	201.00			Domestic	
1342	Union Oil Co	do	E-5	1902	do	338		400		Compressed air				Oil wells	†10
1343	Union Oil Co	do	E-5		Bored, 8-inch	338	270	170		Not raised					
1344	Mr. Chenney	do	E-5		Bored, 7-inch	335	269	81	54	Wind				Domestic	
1345	E. H. Stone	do	E-6	?1897	do	335			40	do				do	

Wells in the Anaheim quadrangle—Continued.

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						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
1346	Jack Hunter	San Juan Cajon	D-6		Bored, 7-inch	327	272	76	56		Wind			Stock	
1347	J. Good	do	D-6	1903	do	310		90	58		Hand	$107.00		Domestic	
1348	T. P. Warne	do	D-5	1895	Bored, 4-inch	328		100	61		Wind			do	
1349	La Habra School District.	La Habra	D-5		Bored, 7-inch	325		90	45		do			do	
1350	C. H. H. Parker	do	D-5	1900	Bored, 10-inch	327	277	118	52	71	do	150.00	$225.00	Domestic; irrigation.	
1351	F. R. Aldrich	do	D-5	1896	Bored, 7-inch	350	130		42		do			Domestic	
1352	J. M. Cusick	do	D-5		Bored, 2-inch	370	220	537	70		do			do	
1353	C. J. Proud	do	D-5	1902	Bored, 10-inch	352	272	430			Not installed			Not used	
1354	F. W. Bishop	do	D-4	1901	Bored, 7-inch	400	100	236	44		Wind			Domestic	
1355	A. L. Roache	do	C-4		Bored, 10-inch	475		265	75		do			do	
1356	do	do	C-4	1900	Bored, 12-inch	475	225	600+			Gas			Irrigation	†17
1357	D. Bastanchury	San Juan Cajon	E-7		Dug, 5-foot diameter.	305	254	53	81		Wind			Domestic; stock	
1358	do	do	E-7	1904	Bored, 12-inch	327		892	70		do			Domestic; irrigation.	
1359	I. B. Varney	La Habra	D-6		Bored, 6-inch	301		100	65		do			do	
1360	C. W. Leffingwell	Santa Gertrudis	A-4	1898	Bored, 10-inch	265	173	583			Compressed air			Irrigation	35
1361	do	do	A-4	1896	do	255	185	282			do			do	10
1362	do	do	A-4	1900	Hydraulic, 3-inch	265	165	605			Gas			do	†3
1363	do	do	A-5		Dug, 3 by 3 foot	247	190	60			Wind			Domestic	
1364	do	do	A-5		Bored, 12-inch, 700 feet; W.	260	188	307			Not raised				

1365	W. W. Dowell	La Habra	A–4		Bored, 7-inch	305	220	190	67		Wind			Domestic		
1366	J. R. Dyer	do	A–4		do	324	205	140	71		do			do		
1367	Scott George	do	B–4	1898	Hydraulic, 3-inch	374	194	537			Not raised					
1368	W. H. Landieth	do	B–5	1899	Bored, 6-inch	360	235	500			Compressed air			Not used		
1369	H. Bush	do	B–5	1896	Hydraulic, 4½-in.	332	234	165	65		Wind			Domestic		
1370	S. M. Smith	do	B–5	1899	Bored, 10-inch	335	252	450			Gas	1,150.00	1,000.00	Irrigation		†30
1371	do	Los Coyotes	B–5	1897	Bored, 7-inch	320	220	140	67		Wind			Domestic		
1372	do	do	B–5	1899	Bored, 8-inch	320	220	200			do			Not used		
1373	Mr. Session	do	B–6		Bored, 7-inch	288	249	162	67		do			Domestic		
1374	J. L. Toler	do	B–6	1875	do	310	165	185	75		do			do		
1375	T. B. Cooper	do	B–6	1904	do	298	247	173	88		Hand			do		
1376	J. A. Gill	do	C–6	1903	do	295	245	123	81		Wind			Domestic; irrigation.		
1377	T. L. Jackson	La Habra	C–5	1900	do	325	285	99	52		do			do		
1378	Jos. Schrott	do	C–5	?1899	Bored, 6-inch	362	252	160	57		do			Domestic		
1379	C. L. McComber	Los Coyotes	A–8	1901	Bored, 5-inch	110	110	285	30		Gas, artesian			Irrigation		†30
1379a	do	do	A–8	1903	Bored, 10-inch	110	105	285			Gas			do		
1380	Tom McFadden	La Habra	D–5	?1903	Dug, 3½-foot diameter.	300	282	19	70		Hand			Domestic		
1381	J. G. Lanner	do	D–5	1898	Bored, 8-inch	320		80	43		Wind, gas			Domestic; irrigation.		
1382	R. C. Hiatt	do	D–5		Bored, 6-inch	312	276	68	45		Wind			Domestic		
1383	H. A. McDonald	do	C–5	1904	Bored, 7-inch	323		120	68		do	147.00	75.00	Domestic; irrigation.		
1384	H. E. Hart	do	C–5		do	328		145	45		do			Domestic		
1385	Thos. Dawson	do	C–5	?1899	do	327	271	80	38		do			do		
1386	C. O. Cook	do	C–5		do	330	271	126	60		Gas			Domestic; irrigation.		
1387	Mrs. Arfwedson	do	C–5		Bored, 8-inch	328	270	109	49		Wind			do		
1388	Harry Little	do	C–5		Bored, 7-inch	310	271	102	64		do			do		
1389	F. D. Chaffee	do	C–6	1897	Bored, 6-inch	295	258	87	82		do	78.00		Domestic		
1390	Mr. Baldwin	do	D–6	1902	Dug, 4-foot diameter.	315	266	54	81		do			do		
1391	J. Leutwiler	do	C–6	1899	Bored, 8-inch	285	251	88	78		do	85.00		do		
1392	J. Leuhm	do	C–5	1897	Bored, 10-inch	305	258	101	73		do			do		
1393	A. L. Roach	do	C–6	1901	Dug, 6 by 6 foot	262	262	30	95		Gas, wind, artesian.			Domestic; irrigation.		†2

Wells in the Anaheim quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
1394	A. L. Roach	La Habra	C-6		Bored, 4-inch	262	262	600+	94	....	Gas, artesian			Irrigation	
1395	M. A. St. Clair	La Puente	H-1	1901	Bored, 10-inch	550	509	100	35	70	Wind	$80.00	$65.00	Domestic; stock	
1396	F. Grazide	do	H-1	1900	Bored, 9½-inch	515	488	83	33	70	Gas			Irrigation	†50
1397	J. Ybarra	do	H-1	1894	Dug, 4 by 4 foot	525	487	40	....	....	Wind		200.00	Domestic; stock	
1398	W. McClintock	do	H-1	1902	Bored, 9½-inch	542	508	64	36	....	Gas	75.00		do	2
1399	Valentine Paton	do	H-1	1901	do	525	....	58	35	69	Flows into tunnel.				
1399a	do	do	H-1	1901	do	525	....	60	35	69	do				
1399b	do	do	H-1	1901	do	525	....	72	35	69	do	400.00	a 8,000.00	Irrigation	†100
1399c	do	do	H-1	1902	do	525	....	80	35	69	do				
1399d	do	do	H-1	1902	do	525	....	90	35	69	do				
1400	J. Ybarra	do	H-1	1901	Bored, 10-inch	505	486	70	....	....	Gas	75.00	400.00	do	
1401	C. B. Ybarra	Rincon De La Brea	H-1	....	Dug, 4 by 3½ foot	525	51	18	60	70	Wind			Domestic; irrigation.	
1402	J. M. Chavy	La Puente	H-1	1904	Dug, 4 by 4 foot	475	459	18	38	....	do			Domestic	
1403	W. H. Howell	Rincon De La Brea	G-1	1899	Bored, 10-inch	475	460	65	45	68	Gas			Irrigation	†55
1404	A. E. Kepner	La Puente	G-1	1900	do	480	460	85	....	....	do	100.00	500.00	do	
1405	B. F. Rowland	do	E-1	1897	do	425	400	270	....	....	do		1,725.00	do	†160
1405a	do	do	E-1	1897	Bored, 10-inch(2)	425	400	140	....	....	do			do	
1406	do	do	E-1	....	Bored, 7-inch	405	367	67	61	....	Wind				
1409	F. Grazide	do	F-2	1903	Bored, 12-inch	500	465	70	68	....	Gas			Domestic; irrigation.	†10
1410	S. A. Middagh	do	G-1	1901	Bored, 10-inch	495	468	70	....	....	Wind			Not used	

Wells in the Santa Ana quadrangle.

[* Cost of well and machinery. † Estimated. + Including tank in column "Cost of machinery". ? Doubtful.]

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water	Depth of well	Solids per 100,000.	Temperature of water	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°F.					*Miner's inches.*
1	A. A. Mallett	Las Bolsas	A-1	1876	Bored, 7-inch	30	30		36		Artesian			Domestic; irrigation; stock.	7
2	J. J. Pyle	do	A-1	1875	do	27	27	107	33	64	do	$105.00		Stock	42
3	O. B. Byram	do	A-1	1875	do	30	30	107	30		do	105.00		Domestic; irrigation; stock.	
4	do	do	A-1	1889	Hydraulic, 3-inch	30	30	110	32		do	57.75		Irrigation	5
5	G. W. Mack	do	A-1	1889	Hydraulic, 2-inch	30	30	110	32		do			do	
6	do	do	A-1	1891	Bored, 7-inch	29	29	107	31		do			Domestic; stock	
7	W. J. Edwards	do	A-1	1875	Bored, 6-inch	33	33	172	30		do			do	22
8	H. R. Case	do	A-1	1900	Hydraulic, 2-inch	27	27	115	33		do			Irrigation; stock	
9	do	do	A-1	1888	Bored, 7-inch	27	27	119	32		do			Domestic; stock	
10	do	do	A-1	1900	Hydraulic, 2-inch	27	27	110			do			Domestic; irrigation.	8
11	J. H. Birch	do	A-1	1888	Bored, 7-inch	28	28	108	33		do	125.00		Domestic; stock.	12
12	do	do	A-1		Bored, 4-inch	28	28	111	33		do			Domestic	
13	Baily Cook	do	A-1	1884	Bored, 7-inch	37	37		33		Artesian, wind			Domestic; stock	
14	do	do	A-1	1900	Hydraulic, 1½-inch.	35	35	114	33		Artesian	30.00		Stock	
15	W. J. Edwards	do	A-1	1900	do	35	35	114	33		do	30.00		do	2
16	do	do	A-1	1896	Bored, 7-inch	32	32	118	33		do	100.00		Domestic; stock	
17	do	do	A-1	1897	Driven, 4-inch	32	32	114	32		do			do	9
18	do	do	A-1	1879	Bored, 7-inch	32	32	110	33		do			Stock	7

Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
19	A. A. Mallett	Las Bolsas	A-1	1876	Bored, 7-inch	30	30				Artesian			Stock	
20	E. D. Linder	do	A-1	1892	do	32	32	108	32		do			Domestic	
21	E. C. Phelps	do	A-1		do	35	35	125	30		do			Irrigation	
22	do	do	A-1		Bored, 3-inch	35	35		32		do			do	
23	J. H. Metzgar	do	A-1	1892	Bored, 2-inch	36	36	112	33		do			Domestic; irrigation; stock.	
24	do	do	A-1		do	37	37		31		do			Irrigation	
25	Dan Head	do	B-1		Hydraulic, 2-inch	38	38		33		do			do	
26	do	do	B-1		do	38	38		32		do			do	
27	Sterling Price	do	B-1	1901	Bored, 4-inch	39	39		34		do			do	14
28	do	do	B-1	1899	Bored, 6-inch	39	39	107	33		do			Stock	
29	do	do	B-1		Hydraulic, 2-inch	40	40	71	34		do			Domestic; stock	3
30	do	do	B-1		Bored, 4-inch	41	41	79	33		do			do	
31	do	do	B-1		do	43	43	110	34		do			Domestic	
32	Mr. Cowtin	do	B-2		Bored, 7-inch	44	44		33					Domestic; stock	
33	C. C. Johnson	do	B-1	1900	Hydraulic, 2-inch	44	44		33		Artesian			do	
34	B. M. Watts	do	B-1	1884	Bored, 8-inch	45	45	90	32		do			do	
35	F. R. Hazzard	do	A, B-1	1894	Bored, 7-inch	45	45	140	33		Siphon			Domestic; irrigation; stock.	
36	Durand estate	do	B-1		do	46	46	124	35		Artesian			Irrigation; stock	2
37	do	do	B-1		do	46	46	129	32		Siphon				
38	German-American Bank	do	B-1		Bored, 4-inch	44	44	125	32		Artesian			Domestic; stock	8

99	R. Pyke	do	E-1	1899	do	50	46	?150	36		do			Domestic; stock	
100	L. M. Steck	do	E-1			49			84		Steam			do	
101	N. N. Farlow	do	E-1	1898	Bored, 4-inch	50	46	115	39		Wind	115.00	60.00	do	
102	do	do	E-1	1898	do	49	45	83	43		Wind; gas	83.00	60.00	Irrigation	
103	Mrs. James Stanley	do	E-1	1896	do	49		130	42		Wind		100.00	Domestic; stock	
104	G. W. Hollister	do	E-1	?1879	do	49	46	111	39		do	50.00	10.00	Domestic; irrigation; stock.	
105	R. M. Phenneger	do	E-2	1878	Bored, 6-inch	47	47		43		do			Domestic; stock	
106	P. De Rosa	do	E-1, 2	1880	Bored, 4-inch	48					Hand			Stock	
107	E. I. Tolle	do	E-2	1874	do	47			43		do			do	
108	Geo. W. Clark	do	E-2	1892	do	48		?110	39		do			Domestic; stock	
109	Wm. Morgan	do	E-2			47		200+	29		Wind			do	
110	E. A. Matthis	do	E-2	1904	Dug, 3 by 3 feet	44	36	9	103		Hand			Domestic	
111	J. S Dameron	do	E-2	1880	Bored, 7-inch	44	42	130	39		do			Domestic; stock	
112	J. Howard Bell	do	E-2		Bored, 4-inch	43	41		41		do			Stock	
113	M. A. Groom	do	E-2	1890	do	45	43	150	36		Wind	175.00	40.00	Domestic; stock	
114	R. P. Mitchell	do	E-2	1902	Bored, 2-inch	45		104	43		Hand	50.00		Domestic	
115	New Hope school district.	do	E, D-2	1895	Bored, 4-inch	45	12	150	37		do			do	
116	Walter D. Lamb	do	D-2	1880	Bored, 3-inch	45	41	104	40		Wind		65.00	Domestic; stock	
117	do	do	D-2	1883	Bored, 5-inch	46	42	130			Not raised			Not used	
118	do	do	D-2	1896	Bored, 4-inch	46	41	111			do			do	
119	A. L. Jesse	do	D-2	?1901	do	46	41	135	35		Wind			Domestic	
121	Mr. Kinsel	do	D-1	1902	Bored, 7-inch	48	43	156	32		Hand			do	
122	A. J. Addington	do	D-1	1886	Bored, 4-inch	48	38	100	39		do			Domestic; stock	
123	F. E. Anderson	do	D-2		Bored, 2-inch	45	42	130	34		do			Domestic	
124	do	do	D-2		Bored, 4-inch	45	42	130			Not raised			Not used	
125	D. E Jessee	do	D-2	1899	Hydraulic, 2-inch	44	42	120	39		Wind	50.00	18.00	Domestic; stock	
126	do	do	D-2		Bored, 4-inch	43	43	100	35		Artesian			Stock	
127	T. E. Chantry	do	D-2		Bored, 7-inch	45	43				Not raised			Not used	
128	J. Willetts	do	D-2		Bored, 4-inch	44			37		Wind			Domestic; stock	
129	N. Bower	do	D-2	?1892	do	44	44	106	33		Artesian			do	
130	J. C. Jones	do	D-2	1898	Hydraulic, 3-inch	45	42	120	31		Hand			do	
131	C. W. Warner	do	D-2	1898	Bored, 4-inch	45	41	?116	31		Wind	86.00	20.00	do	
132	Marshall Vawters	do	D-2	1898	do	46	42	258	29		Wind; hand			do	
133	Henry Davis	do	D-1	1903	Driven, 1¼-inch	49		15	37		Hand	5.00		Domestic	

Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
74	A. Leatherman	Las Bolsas	D-1	1890	Bored, 4-inch	60	55	112	37		Horsepower		$160.00	Domestic; stock	40
76	Moter Helney	do	D-1		do	55	54	87			Wind			Not used	
77	Mr. Addington	do	D-1		do	53	53		34		Artesian			Stock	
78	J. M. Wallace	do	D-1		do	52	46		35		Wind			Domestic; stock	
79	J. E. Hodges	do	D-1	1890	do	52	43	125	39		Hand	$110.00		do	
80	E. B. Lunsford	do	D-1		do	50	44		33		Wind			do	
81	Mr. Blackburn	do	D-1	1895	Bored, 2-inch	50		112	35		do			Domestic	
82	J. W. Vawter	do	D-1	?1892	Bored, 7-inch	50		393	35		do			Domestic; stock	
83	do	do	D-1	1900	do	55	48	165	27		Gas	188.00	300.00	Irrigation	†20
84	W. A. Plument	do	D-1		Bored, 4-inch	49			37		Hand			Domestic; stock	
85	A. J. McArthur	do	D-1	1897	Hydraulic, 2-inch	55		165	23		Wind	70.00	55.00	do	
86	E. A. Teal	do	D-1	1896	Bored, 4-inch	58	46	?140	27		do			Domestic	
87	Elizabeth Rosemeyer	do	D-1	1890	Bored, 7-inch	55	47	150	40		Hand			Domestic; stock	
89	J. D. Price	do	E-1	1892	Bored, 4-inch	58	46	107	25		do	95.00		Stock	
90	Orange Co	do	E-1	1900	Bored, 7-inch	55	47	150			Horsepower			Not used	
91	C. W. Blankenbeckler	do	E-1	?1884	do	55	47	117	39		Wind, hand			Domestic	
92	Alexander Alec	do	E-1	1891	do	55	48	150	33		Hand			do	
94	Joe McCormick	do	E-1	1890	Bored, 4-inch	60	48		38		do			Domestic; stock	
95	Mrs. Chrisp	do	E-1	1889	do	55	47	150	42		Wind, hand			do	
96	Mr. Wallace	do	E-1	1903	Bored, 7-inch	53		86	36		Hand			Stock	
97	J. F. Stacey	do	E-1	1890	Bored, 4-inch	55	47	168	32						
98	Mr. Head	do	E-1	1903	do	52	49		40		Wind			Stock	

99	R. Pyke	do	E-1	1899	do	50	46	?150	36	do			do	
100	L. M. Steck	do	E-1			49			34	Steam			do	
101	N. N. Farlow	do	E-1	1898	Bored, 4-inch	50	46	115	39	Wind	115.00	60.00	do	
102	do	do	E-1	1898	do	49	45	83	43	Wind; gas	83.00	60.00	Irrigation	
103	Mrs. James Stanley	do	E.1	1896	do	49		130	42	Wind		100.00	Domestic; stock	
104	G. W. Hollister	do	E-1	?1879	do	49	46	111	39	do	50.00	10.00	Domestic; irrigation; stock.	
105	R. M. Phenneger	do	E-2	1878	Bored, 6-inch	47	47		43	do			Domestic; stock	
106	P. De Rosa	do	E-1,2	1880	Bored, 4-inch	48				Hand			Stock	
107	E. I. Tolle	do	E-2	1874	do	47			43	do			do	
108	Geo. W. Clark	do	E-2	1892	do	48		?110	39	do			Domestic; stock	
109	Wm. Morgan	do	E-2			47		200+	29	Wind			do	
110	E. A. Matthis	do	E-2	1904	Dug, 3 by 3 feet	44	36	9	103	Hand			Domestic	
111	J. S. Dameron	do	E-2	1880	Bored, 7-inch	44	42	130	39	do			Domestic; stock	
112	J. Howard Bell	do	E-2		Bored, 4-inch	43	41		41	do			Stock	
113	M. A. Groom	do	E-2	1890	do	45	43	150	36	Wind	175.00	40.00	Domestic; stock	
114	R. P. Mitchell	do	E-2	1902	Bored, 2-inch	45		104	43	Hand	50.00		Domestic	
115	New Hope school district.	do	E, D-2	1885	Bored, 4-inch	45	42	150	37	do			do	
116	Walter D. Lamb	do	D-2	1880	Bored, 3-inch	45	41	104	40	Wind		65.00	Domestic; stock	
117	do	do	D-2	1893	Bored, 5-inch	46	42	130		Not raised			Not used	
118	do	do	D-2	1896	Bored, 4-inch	46	41	111		do			do	
119	A. L. Jesse	do	D-2	?1901	do	46	41	135	35	Wind			Domestic	
121	Mr. Kinsel	do	D-1	1902	Bored, 7-inch	48	43	156	32	Hand			do	
122	A. J. Addington	do	D-1	1886	Bored, 4-inch	48	38	100	39	do			Domestic; stock	
123	F. E. Anderson	do	D-2		Bored, 2-inch	45	42	130	34	do			Domestic	
124	do	do	D-2		Bored, 4-inch	45	42	130		Not raised			Not used	
125	D. E. Jessee	do	D-2	1899	Hydraulic, 2-inch	44	42	120	39	Wind	50.00	18.00	Domestic; stock	
126	do	do	D-2		Bored, 4-inch	43	43	100	35	Artesian			Stock	
127	T. E. Chantry	do	D-2		Bored, 7-inch	45	43			Not raised			Not used	
128	J. Willetts	do	D-2		Bored, 4-inch	44			37	Wind			Domestic; stock	
129	N. Bower	do	D-2	?1892	do	44	44	106	33	Artesian			do	
130	J. C. Jones	do	D-2	1898	Hydraulic, 3-inch	45	42	120	31	Hand			do	
131	C. W. Warner	do	D-2	1898	Bored, 4-inch	45	41	?116	31	Wind	86.00	20.00	do	
132	Marshall Vawters	do	D-2	1898	do	46	42	258	29	Wind; hand			do	
133	Henry Davis	do	D-1	1903	Driven, 1¼-inch	49		15	37	Hand	5.00		Domestic	

Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
134	A. Jessee	Las Bolsas	D-1	1897	Hydraulic, 2-inch	49		115	39		Hand	$47.00		Domestic; stock	
135	Leonard Davis	do	D-1	1903	Driven, 1¼-inch	50		16	67		do	6.00		Domestic	
136	J. D. Addington	do	D-1	?1891	Bored, 4-inch	50	42	110	39		Hand, horse-power.			Domestic; stock	
137	D. W. Head	do	D-1	?1886		51			37		Hand			do	
138	Eugene Pohl	do	D-2		Bored, 4-inch	44	44	115	33		Artesian			Domestic	
139	A. Leatherman	do	D-2	1896	do	43	43	80	31		do			Stock	
140	T. J. Fowler	do	D-2	1900	Bored, 2-inch	43	43		32		do			Domestic	
141	do	do	D-2	1900	Bored, 4-inch	45	45		33	64	do			Stock	
142	Eugene Pohl	do	D-2		do	43	43	118	32	64	do			do	
143	W. M. Ward	do	C-2	1896	Hydraulic, 2-inch	42	42		35	64	do	100.00			
144	Geo. Covalt	do	C-2		Bored, 7-inch	42	42	103	35	65	do			Domestic; stock	
145	Alexander Strouthers.	do	C-2			42	42	123	35		do	81.35		do	
146	do	do	C-2		Bored, 7-inch	45	45	116	38		do			Irrigation; stock	
147	do	do	C-2		do	43	43	?116	40		do			Stock	
148	do	do	C-2		do	42	42	122	42	65	do			Domestic; irrigation.	7
149	N. Burwell	do	C-2	1899	Hydraulic, 2-inch	42	42	115	32	67	do	40.00		Domestic; stock	2
150	do	do	C-2	1900	Bored, 7-inch	42	42	115			do	115.00		Irrigation	
151	do	do	C-2		do	41	41	115	33		do	115.00		do	
152	do	do	C-2	1900	Hydraulic, 2-inch	42	42	115	32	67	do			Stock	
153	Silas Wright	do	C-2	1900	do	42	42	102	32	66	do			do	4

209	David Stewart	....do	A-1		....do	34	34	100	32	65	....do			Domestic; stock			
211	J. P. Walker	....do	A-1	1889	....do	32	32	100	32	65	....do			Domestic; irrigation; stock.			
212	Mary Mefford	....do	A-1	1896	....do	31	31	100+	31	65	....do			Domestic; stock			
213	....do	....do	A-1	1900	Bored, 7-inch	30	30	100+	31	65	....do			....do			
214	Jas. McMillan	....do	A-2	1885	Bored, 4-inch	29	29	86	32	65	....do			....do			
215	....do	....do	A-2	1894	....do	30	30	100+	30		....do			Stock			
216	Oliver Stewart	....do	A-2		....do	32	32	110	33	64	....do			Domestic; stock			
217	David Stewart	....do	A-2		....do	32	32		31	64	....do			....do			
219	Golden West Celery Co	La Bolsa Chica	A-2	1888	Bored, 7-inch	26	26	100	31		....do			Irrigation			
220	....do	....do	A-2		....do	24	24	98	32		....do			Domestic			
221	B. F. Townsend	....do	A-2		....do	24	24		28	63	....do			Domestic; stock			
222	W. L. James	....do	A-2	1899	....do	26	26	96	32	64	....do	100.00		....do		29	
223	....do	....do	A-2	1901	Bored, 6-inch	27	27		25		....do	100.00		Irrigation		55	
224	....do	....do	A-3	1904	Bored, 4-inch	27	27	69	32	64	....do	45.00		....do		8	
227	B. F. Townsend	....do	A-2		Hydraulic, 2-inch	22	22		30	64	....do					4	
228	....do	....do	A-2		Bored, 7-inch	22	22		24		....do			Irrigation; stock			
229	....do	....do	A-2		....do	22	22		31		....do			Irrigation			
230	....do	....do	A-2		....do	23	23		30		....do			....do			
231	....do	....do	A-2		....do	24	24		31	63	....do			....do			
232	Southern Pacific R. R. Co.	....do	A-2		....do	22	22		31	64	Steam, artesian			Locomotives			
233	John Langdon	....do	A-2		Hydraulic, 2-inch	20	20		29	63	Artesian			Domestic; stock			
234	....do	....do	A-2		Bored, 4-inch	20	20	75	25		....do			Irrigation		18	
235	....do	....do	A-3	1903	Bored, 6-inch	20	20	175	29	63	....do			....do		38	
236	Mr. Stolp	Las Bolsas	A-3		Bored, 7-inch	22	22		28	64	....do			Domestic; irrigation; stock.			
237	....do	....do	A-3		Bored, 4-inch	22	22		27	63	....do			Irrigation			
238	....do	....do	A-3		....do	21	21		22		....do			....do			
239	James Cain	La Bolsa Chica	A-3		Bored, 7-inch	25	25	300+	24	64	....do			Domestic; stock			
240	....do	Las Bolsas	A-3		Hydraulic, 2-inch	25	25		29	64	....do			Stock			
241	M. F. McDonnell	....do	A-3		Hydraulic, 1½-inch.	25	25		28	63	....do			....do			
242	Eugene Pohl	....do	A-3	1902	Hydraulic, 2-inch	24	24	171	35		....do			Domestic; stock			
243	....do	....do	A-3		Bored, 4-inch	24	24	156	140		....do			Irrigation; stock			
244	J. S. Collings	.... do	A-3	1891	Hydraulic, 2-inch	23	23	90	27		....do			Domestic			

Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
189	J. R. Fowler	Las Bolsas	B-1, 2	1901	Hydraulic, 3-inch	43	43	95	32	65	Artesian			Stock	
190	do	do	C-1	1901	do	45	45	118			do	$81.00		Irrigation	
191	Will Cheney	do	C-1	1900	Bored, 7-inch	47	47	?160	32		do	170.00		do	2
192	German-American Bank.	do	B-1		do	47	47	124	33	65	do			do	7
193	do	do	B-1		do	47	47				do			do	
194	Will Cheney	do	C-1	1900	Hydraulic, 3-inch	46	46	280	32	65	do	13.20		do	18
195	Mrs. McFadden	do	C-2	1900	Hydraulic, 4-inch	45	45	280	33	65	do	40.00		do	†17
196	Golden West Celery Co.	do	D-2		Bored, 7-inch	32	32		33	65	do			Domestic; irrigation.	
197	J. T. Worthy	do	B-2		Hydraulic, 2-inch	30	30		31	66	do			Domestic	
198	Oliver Stewart	do	A-2		Bored, 7-inch	32	32	112	32		do			Irrigation	
199	do	do	A-2	1903	Bored, 4-inch	32	32	110	33		do			do	
200	David Stewart	do	A-2		Hydraulic, 2-inch	29	29	110	37		do			do	
201	E. P. Justice	do	A-1	1884	Bored, 4-inch	35	35	114	32	65	do	90.00		Domestic; stock	
202	do	do	A-1	1897	do	35	35	114	32	65	do	90.00		do	1
203	do	do	A-1, 2	1894	do	32	32	96	32	65	do			Domestic; irrigation.	1
204	Mrs. Steltzer	do	A-1	1899	do	32	32	100	31	65	do			Domestic; stock	
205	M. F. McDonnell	do	A-1	1899	Bored, 7-inch	36	36	190	29	64	do	102.00		Domestic; irrigation; stock.	2
206	do	do	A-1	1890	Hydraulic, 2-inch	36	36	90	32	65	do			do	
207	Walker & Co	do	A-1		do	91	0							Stock	

209	David Stewart	do	A-1		do	34	34	100	32	65	do			Domestic; stock		
211	J. P. Walker	do	A-1	1889	do	32	32	100	32	65	do			Domestic; irrigation; stock.		
212	Mary Mefford	do	A-1	1896	do	31	31	100+	31	65	do			Domestic; stock		
213	do	do	A-1	1900	Bored, 7-inch	30	30	100+	31	65	do			do		
214	Jas. McMillan	do	A-2	1885	Bored, 4-inch	29	29	86	32	65	do			do		
215	do	do	A-2	1894	do	30	30	100+	30		do			Stock		
216	Oliver Stewart	do	A-2		do	32	32	110	33	64	do			Domestic; stock		
217	David Stewart	do	A-2		do	32	32		31	64	do			do		
219	Golden West Celery Co	La Bolsa Chica	A-2	1888	Bored, 7-inch	26	26	100	31		do			Irrigation		
220	do	do	A-2		do	24	24	98	32		do			Domestic		
221	B. F. Townsend	do	A-2		do	24	24		23	63	do			Domestic; stock		
222	W. L. James	do	A-2	1899	do	26	26	96	32	61	do	100.00		do		29
223	do	do	A-2	1901	Bored, 6-inch	27	27		25		do	100.00		Irrigation		55
224	do	do	A-3	1904	Bored, 4-inch	27	27	69	32	64	do	45.00		do		8
227	B. F. Townsend	do	A-2		Hydraulic, 2-inch	22	22		30	64	do					4
228	do	do	A-2		Bored, 7-inch	22	22		24		do			Irrigation; stock		
229	do	do	A-2		do	22	22		31		do			Irrigation		
230	do	do	A-2		do	23	23		30		do			do		
231	do	do	A-2		do	24	24		31	63	do			do		
232	Southern Pacific R. R. Co.	do	A-2		do	22	22		31	64	Steam, artesian			Locomotives		
233	John Langdon	do	A-2		Hydraulic, 2-inch	20	20		29	63	Artesian			Domestic; stock		
234	do	do	A-2		Bored, 4-inch	20	20	75	25		do			Irrigation		18
235	do	do	A-3	1903	Bored, 6-inch	20	20	175	29	63	do			do		38
236	Mr. Stolp	Las Bolsas	A-3		Bored, 7-inch	22	22		28	64	do			Domestic; irrigation; stock.		
237	do	do	A-3		Bored, 4-inch	22	22		27	63	do			Irrigation		
238	do	do	A-3		do	21	21		22		do			do		
239	James Cain	La Bolsa Chica	A-3		Bored, 7-inch	25	25	300+	24	64	do			Domestic; stock		
240	do	Las Bolsas	A-3		Hydraulic, 2-inch	25	25		29	64	do			Stock		
241	M. F. McDonnell	do	A-3		Hydraulic, 1½-inch.	25	25		28	63	do			do		
242	Eugene Pohl	do	A-3	1902	Hydraulic, 2-inch	24	24	171	35		do			Domestic; stock		
243	do	do	A-3		Bored, 4-inch	24	24	156	140		do			Irrigation; stock		
244	J. S. Collings	do	A-3	1891	Hydraulic, 2-inch	23	23	90	27		do			Domestic		

Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
245	Mrs. A. Brush	Las Bolsas	A-2	1882	Bored, 4-inch	27	27	96	32	61	Artesian			Domestic; stock	
246	do	do	A-2	1899	Bored, 7-inch	27	27	300+	29		do			Irrigation	
247	Ocean View school district.	do	A-2		Bored, 4-inch	27	27		31	62	do			Domestic	
248	David Brush	do	A-2	1884	do	27	27	65	33	62	do			Stock	
249	Mr. Waddell	do	A-2		Hydraulic, 2-inch	27	27		31	62	do			do	
250	David Brush	do	A-2	1887	do	27	27		31	62	do			Domestic; stock	
251	do	do	A-2	1896	do	29	29		34	62	do			Stock	
252	do	La Bolsa Chica	A-2	1899	Bored, 4-inch	27	27		31	62	do			Irrigation	
253	John McFadden	do	A-2		do	27	27		31		do			Domestic; stock	
254	do	do	A-2		do	27	27		30	62	do			Stock	
255	Mr. Waddell	Las Bolsas	A-2		do	26	26		25		do			Domestic; stock	
256	S. C. Thompson	do	A-2	1902	do	23	23	789	27	61	do	$100.00+		Irrigation; stock	
257	do	do	A-2	1902	Hydraulic, 3-inch	24	24	789			do			Irrigation	
258	do	do	A-3	1903	Hydraulic, 2-inch	22	22	115	29		do	88.00		do	8
259	J. M. Hall	do	A-3	1899	Bored, 7-inch	22	22	150	28	60	do			Irrigation; stock	10
260	do	do	A-2	1900	Hydraulic, 2-inch	23	23	216	28	62	do			Irrigation	
261	do	do	A-2	1898		23	23	215	29		do	126.00		do	
262	V. F. Barnes	do	A-3	1901	Hydraulic, 2-inch	22	22	170+	29	61	do			Domestic; stock	
263	L. L. Stolp	do	A-3	1903	Hydraulic, 3-inch	23	23		27	60	do			do	
264	J. S. Collings	do	A-3	1904	Hydraulic, 4-inch	24	24	171	31		do	111.15		Irrigation	20
265	do	do	A-3	1901	Bored, 7-inch	25	25	?186	30		do			do	
266	J. T. Stockton	do	A-3		Hydraulic, 2-inch	28	28		27		do			Domestic; stock	

			A-3	1904	Bored, 7-inch									Domestic; irrigation; stock.		
268	D. C. Tauts	do	A-3	1900	Hydraulic, 2-inch	32	32	225	28	63	do			do		
269	do	do	A-3	1899	Hydraulic, 3-inch	28	28	176	26		do			Irrigation		
270	Mr. Stewart	do	A-3	1904	Hydraulic, 2-inch	26	26	200+	28		do			Irrigation; stock		4
271	J. Brush	do	A-3	1899	do	25	25	100+	28		do			Domestic; stock		
272	do	do	A-3	1892	do	23	23	100	29		do			Stock		5
273	do	do	A-3	1894	Bored, 4-inch	23	23	?140	28		do			do		
275	W. H. Young	do	B-2		do	24	24		30	62	do			Domestic; stock		
277	C. A. S. Howard	do	B-3		Bored, 7-inch	26	26	300+	26		do			Irrigation		
278	do	do	B-3		Bored, 4-inch	26	26	64	29	59	Not raised			Not used		
279	G. H. McGill	do	B-2	1897	Hydraulic, 2-inch	26	26	96	30	60	Artesian			Domestic		
280	do	do	B-2, 3	1892	Bored, 4-inch	26	26	100	42	62	do	85.00		Stock		
281	do	do	B-3	1892	do	27	27	118	29	61	do	85.00		Irrigation		
282	W. H. Young	do	B-2		Bored, 7-inch	27	27	115	32	62	do			Domestic; irrigation; stock.		7
283	Lewis Heil	do	B-2	1897	Bored, 4-inch	30	30	99	29	62	do			Domestic; stock		
284	do	do	B-2	1899	Bored, 7-inch	32	32	128	27	62	do	138.00		Irrigation; stock		
285	do	do	B-2	1896	do	36	36	99	31	62	do	100.00		Irrigation		
286	do	do	B-3	1902	do	36	36	150	25	62	do			do		
287	W. H. Young	do	B-2		do	30	30		32	62	do			do		
288	Fred Heil	do	B-2	1903	Hydraulic, 2-inch	32	32		32	63	do			Stock		
289	do	do	B-2	1896	do	34	34	98	33	63	do			Domestic; stock		
290	do	do	B-2	1898	Hydraulic, 3-inch	33	33		29	63	do			Irrigation		
291	do	do	B-2	1900	Bored, 7-inch	33	33		31	62	do			do		
292	do	do	B-2	1900	do	34	34		31	62	do			do		
293	do	do	B-2	1900	do	35	35		30	63	do			do		
294	do	do	B-2	1898	Hydraulic, 2-inch	35	35	98	31	62	do			do		
295	do	do	B-2	1898	do	35	35	?100	29	62	do			do		4
296	Mr. Hemstock	do	B-3		do	36	36	100	31	63	do			Domestic		4
297	do	do	B-3		Bored, 4-inch	31	31		30	65	do			Irrigation		
298	M. C. Adams	do	B-3	1901	Hydraulic, 2-inch	29	29	100+	31	65	do			do		2
299	do	do	B-3	1900	do	30	30	100	28	64	do			Domestic; stock		
300	L. Decius	do	B-3		Bored, 7-inch	30	30	125	29	65	do			Irrigation		1
301	Robt. Elliot	do	B-3		Hydraulic, 2-inch	31	31		29	64	do			Domestic; stock		

Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Fret.*		°*F.*					*Miner's inches.*
302	Robt. Elliott	Las Bolsas	B-3		Bored, 7-inch	33	33		31	64	Artesian			Irrigation	
303	do	do	B-3		Hydraulic, 2-inch	33	33		36	66	do			do	
304	Jeff Leak	do	B-3		Bored, 7-inch	32	32	135	35	64	do			do	
305	G. L. Bayless	do	B-3		Hydraulic, 1¼-inch.	31	31		31	62	do			Domestic; stock	
306	Jeff Leak	do	B-3		Hydraulic, 2-inch	31	31		31	63	do			Irrigation	
307	Geo. Marcoyama	do	B-3		do	27	27	75	30	64	do			Domestic; stock	4
308	do	do	B-3		Bored, 3-inch	27	27	75	30	64	do			Irrigation	
309	D. C. Fauts	do	B-3	1901	Bored, 7-inch	30	30	200	27	64	do			Irrigation; stock	42
310	do	do	B-3	1900	Hydraulic, 3-inch	30	30	176	27	64	do			do	8
311	Mr. Fox	do	B-3		Bored, 7-inch	33	33		29	64	do			Irrigation	
312	C. A. Fowler	do	B-3		Hydraulic, 2-inch	33	33		29	65	do			Domestic; irrigation; stock.	
313	do	do	B-3		Hydraulic, 1¼-inch.	33	33		32	66	do			Irrigation	
314	do	do	B-3		Hydraulic, 2-inch	32	32		30	66	do			do	
315	Mrs. Williams	do	B-3	1897	Bored, 4-inch	34	34	140	31	65	do	$213.00		do	
316	J. C. McDowell	do	B-3	1902	Bored, 7-inch	33	33	144			do			do	95
317	Mr. Fox	do	B-3		Bored, 4-inch	32	32		30	64	do			do	
318	do	do	B-3		Bored, 7-inch	33	33		27	65	do			do	
319	J. C. McDowell	do	B-3	1899	Hydraulic, 2-inch	33	33	99	32	65	do			Domestic; stock	
320	C. W. Fox	do	B-3		Bored, 2-inch	35	35		31	65	do				
321	John L. Adams	do	B, C-3		Hydraulic, 3-inch	35	35	80	30	64	do				
322	do	do	C-3		Hydraulic, 2-inch	35	35		33		do				

327	C. McDowell	do	C-3		Hydraulic, 1½-inch.	33	33		28	63	do			Domestic; stock		
329	Silas Wright	do	C-2	1895	Bored, 7-inch	41	41	88	31	61	do	88.00		Irrigation; stock		19
330	do	do	C-2	1895	Hydraulic, 2-inch	40	40	80	30	63	do			Irrigation		
331	do	do	C-2	1895	do	41	41	103	32	63	do			Irrigation; stock		
332	do	do	C-2	1884	Bored, 4-inch	41	41	106	31	63	do	74.20		do		15
333	do	do	C-2	1879	Hydraulic, 4-inch	39	39	102	31	63	do			do		
334	Frank Beswick	do	C-2		Hydraulic, 2-inch	39	39		34		do			do		2
335	Silas Wright	do	C-2	1897	Bored, 7-inch	39	39	109	26	62	do	109.00		Irrigation		42
336	do	do	C-2	1895	Hydraulic, 2-inch	39	39	106	30	64	do	36.00		Irrigation; stock		
337	Lewis Heil	do	C-2	1896	do	38	38	94	32	64	do			do		4
338	R. R. McDowell	do	C-3	1898	Hydraulic, 3-inch	37	37	85	31	64	do			Domestic; stock		
339	James Lintott	do	C-3		Hydraulic, 2-inch	35	35		33	64	do			do		
340	do	do	C-3		do	35	35		32	64	do			Irrigation		
341	W. A. Jones	do	C-3	1903	Bored, 4-inch	36	36	97	31	65	do	75.00		Domestic; irrigation; stock.		
342	Mrs. M. F. Jepsen	do	C-3	1900	Hydraulic, 2-inch	37	37		26	65	do			do		
343	do	do	C-3	1900	Bored, 4-inch	37	37	94	31	65	do			Irrigation; stock		20
344	J. S. Rice	do	C-3	1884	do	38	38		31	64	do			Domestic; irrigation; stock.		
345	Robert Graham	do	D-3		do	39	39	96	32	65	do			do		4
346	M. B. Price	do	C-3	1884	do	40	40		31		do					
347	I. Harshlan	do	D-3	1899	Hydraulic, 2½-inch.	37	37	76	32	65	do	35.00		Domestic; stock		6
348	do	do	C-3		Bored, 4-inch	37	37	100+	27	64	do			Irrigation		
349	S. H. Overacker	do	D-3	1902	do	37	37	101	34	65	do	70.00		do		14
350	do	do	D-3	1900	Hydraulic, 2-inch	36	36	96	33	64	do	41.00		do		
351	G. A. Winn	do	D-3	1903	Bored, 7-inch	39	39	97	35	64	do			Domestic; irrigation; stock.		12
352	do	do	D-3		Hydraulic, 4-inch	40	40	89	32	63	do			Irrigation		
353	Eugene Pohl	do	D-2		Bored, 4-inch	43	43	125	35	63	do			Domestic; irrigation; stock.		
354	do	do	D-2		do	42	42	120	30	64	do			Irrigation; stock		

Wells in the Santa Ana quadrangle—Continued.

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						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
355	Eugene Pohl	Las Bolsas	D-2		Bored, 4-inch	42	42	122	32	64	Artesian			Irrigation; stock	
356	Silas Wright	do	C-2	1895	Bored, 7-inch	40	40	102	33	65	do			do	
357	J. P. Jaques	do	D-2	1903	do	42	42	116	36	66	do	$160.00		Domestic; stock	
358	S. H. Overacker	do	D-2	1898	Bored, 4-inch	41	41	98	35	65	do	75.00		do	
359	Chas. O'Donnell	do	D-3	1903	Bored, 7-inch	40	40	101	34	67	do			Irrigation; stock	19
360	T. J. Williams	do	D-3	1888	Hydraulic, 4-inch	40	40	142	35		do	150.00		Stock	
361	do	do	D-3	1884	Bored, 6-inch	41	41	160	35	66	Not raised			Not used	
362	do	do	D-3	1884	Bored, 4-inch	40	40	140	35		Artesian, hand			Domestic; irrigation.	
363	H. A. Williams	do	D-3	1874	do	37	37	100	33		do			Domestic; stock	
364	do	do	D-3	1874	do	37	36	110	34	66	Horsepower		$160.00	Irrigation	30
365	do	do	D-3	1904	Bored, 7-inch	37	37	164			Gas	113.00	700.00	do	
366	John Smith	do	D-3	1899	Hydraulic, 2-inch	37	37	107	35	66	Artesian			Stock	Small.
367	Mr. Martin	do	E-3	1874	Hydraulic, 3-inch	38	38	115	38		do			do	Small.
369	Mr. Bates	do	D-3	1902	Hydraulic, 2-inch	35	35	116	33	65	do			Irrigation	4
370	do	do	D-3	1902		34	34		31		do			do	Small.
371	J. P. Jaques	do	D-3		Bored, 4-inch	36	36		33	64	do			Stock	Small.
372	M. T. Doig	do	D-2	1884	do	41	41	130	36	65	Wind			Domestic; stock	
373	do	do	D-2	1884	do	41	41	130			Artesian			Irrigation; stock	
374	W. A. Bedford	do	D-2		do	41			35	65	Hand				
375	J. E. Ann	do	D-2	1902	do	41	41	160	30	64	do	180.00		Domestic; stock	
376	E. Butts	do	E-2		do	42	42		38	62	do			do	
377	J. T. Smith	do	D-2	1899	Bored, 2-inch	43	41	130	36	61	do			do	

378	W. A. Bedford	do	E-2	1884	Bored, 4-inch	43	42	90			Not flowing			Irrigation		
379	F. E. Anderson	do	D-2		do	43	43	112	35	63	Artesian			Irrigation		
381	E. L. Elliott	do	E-3	?1883	do	34	34	104	33	64	do			Domestic; stock		
382	Geo. Brown	do	E-2		Hydraulic, 1¼-inch.	34	34		30		do			Stock		
383	L. W. Weary	do	E-3, 4	?1884	Bored, 4-inch	34	24	104			Hand			Domestic; stock		
384	Jasper Botchard	do	D-3, 4		Hydraulic, 3-inch	34	34	116	31	64	Artesian			Irrigation; stock		8
385	do	do	D-3		Bored, 3-inch	34	34	104	31	64	do			do		
386	do	do	D-4		Hydraulic, 3-inch	34	34		32		do			do		12
387	S. J. Pankey	do	D-3		Bored, 4-inch	35	35	100+	35	63	do			Domestic; stock		
388	B. B. Miller	do	D-3	1904	Hydraulic, 1¼-inch.	36	36	96	33	63	do			do		
391	Caspar Borchard	do	D-4	?1902	Hydraulic, 2-inch	32	32	120	31	61	do			do		4
392	Von Suelts	do	E-4		Bored, 4-inch	32	32				do			Stock		
393	A. F. Hallstrom	do	E-4	1903	Bored, 7-inch	32	32	400	29		do			Domestic; stock		Small.
394	Mr. Hoskins	do	E-4	1903	Bored, 4-inch	33	33	340	25		Artesian, gas			Irrigation		Small.
395	do	do	E-4	1903	Bored, 6-inch	34	34	300+	28	68	do			do		Small.
396	John DeVenney	do	E-4	?1889	Bored, 7-inch	33		126	28	64	Artesian			Domestic; stock		
397	Mr. DeWitt	do	E-3		Bored, 4-inch	33	33	79	33	64	do			Irrigation; stock		Small.
398	Mr. Black	do	D-4		do	32	32	98	29	63	do			Stock		Small.
400	Frank Thompson	do	C-4	1900	Hydraulic, 1¼-inch.	33	33	82	32	63	do			Domestic; stock		
401	G. W. Brown	do	C-4	1898	Bored, 2-inch	35	35	100	31	64	do			Domestic; irrigation.		1
402	do	do	D-4	1900	do	34	34	125			do			Irrigation		1
403	Wm. Hammer	do	C-4		do	35	35	90	32	64	do			Stock		3
404	Mrs. Roberts	do	D-3		do	39	39		33	64	do			Irrigation; stock		
405	J. H. Hoff	do	C-3	1903	Bored, 4-inch	37	37	99	35	64	do			Irrigation		4
406	S. Breutlinger	do	C-3	1903	Bored, 2-inch	37	37	100			do			Domestic; stock		
407	G. A. Warner	do	C-3	1904	do	36	36	98	30	64	do			Domestic; irrigation.		2
408	N. D. Helms	do	C-3	1904	Bored, 3-inch	36	36	83	30	64	do			Irrigation		3
409	L. D. Rush	do	C-4	1900	Bored, 2-inch	33	33	90	32	64	do			Domestic; irrigation.		3
410	Dan Gerson	do	C-4	?1898	Bored, 4-inch	33	33	100	32	64	do			Irrigation		5
411	Oswald Kutzner	do	C-4	1900	Bored, 2-inch	30	30	96	32	64	do			do		4
412	B. G. Page	do	C-4	1904	do	30	30	102	33	64	do			Domestic		Small.

Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°F.					*Miner's inches.*
413	Geo. Dixon	Las Bolsas	D-4	1898	Bored, 2-inch	30	30	96	32	64	Artesian			Domestic; irrigation.	4
414	do	do	D-4	1898	do	31	31	96	32	64	do			Irrigation	4
415	O. H. Ellis	do	D-4	1903	do	29	29	96	32		do			Domestic; stock	2
416	do	do	D-5	1898	do	27	27	96			do			Stock	2
417	Wm. Dunn	do	C-4		Bored, 3½-inch	31	31	98	33	64	do			Irrigation	
418	W. H. Sprouls	do	C-4	1901	Bored, 2-inch	32	32	90	31	64	do			Domestic; stock	
419	Mrs. M. Page	do	C-4	1904	do	32	32	90	33	64	do			Domestic; irrigation.	5
420	do	do	C-4	1900	do	33	33	93			do			Irrigation	4
422	L. A. Lindsay	do	C-4	1902	Bored, 3-inch	34	34	83	31	64	do			Domestic; stock	3
423	Mrs. Nimocks	do	C-4	1896	Bored, 7-inch	35	35	84	32	64	Artesian, gas			Domestic	Small.
424	T. P. McWaters	do	C-4	1901	Bored, 2-inch	36	36	86			Artesian			Irrigation	2
425	Bowman Martin	do	C-4	1898	Bored, 3-inch	37	37	78	31	64	do			Irrigation; stock	11
426	John Walsh	do	C-4	1885	Bored, 4-inch	36	36	70	29	64	do			Domestic; stock	
427	Bowman Martin	do	C-4		Bored, 2-inch	37	37				do			Irrigation	2
428	R. J. Cary	do	C-3		do	38	38	86	31		do			Domestic; stock	
430	Mr. Dundas	do	C-3		do	38	38		33	64	do			Irrigation; stock	Small.
431	do	do	C-3		do	37	37				do			Irrigation	2
432	J. R. Cary	do	C-3	1897	do	37	37	110	32	64	do			Domestic	3
433	do	do	C-3	1897	do	37	37	115			do			Stock	4
434	do	do	C-3		Bored, 7-inch	37	37	110			Not raised			Not used	
435	James Cox	do	C-4		Bored, 2-inch	36	36	79	31	63	do			Domestic; stock	1

438	Harry West	do	C-5	1900	do	33	33	75			do			Domestic; stock	
439	do	do	C-5	1899	Bored, 3-inch	33	33	80	28	64	do			Irrigation	2
442	Omie Ater	do	C-4	1900	Bored, 2-inch	37	37	90			do			do	4
443	W. F. Taylor	do	C-4	?1884	Bored, 7-inch	37	37	100	33	64	do			do	8
444	Talbert school district	do	B-4	1898	Bored, 2-inch	37	37	?100	31	64	do			Domestic	
445	J. H. Cox	do	C-4	1900	do	37	37	91	31	64	do			Irrigation	Small.
446	A. Martel	do	B-4	1898	do	37	37	100	32		do			Domestic; irrigation.	1
447	do	do	C-4	1897	do	37	37	100			do			Irrigation	
448	J. H. Cox	do	C-4	1903	do	37	37	90	31	64	do			do	2
449	R. B. Wardlow	do	B-4	1897	Bored, 4-inch	38	38	84	32	64	Artesian, wind			Domestic; stock	
450	do	do	B-4	1904	do	38	38	90			Artesian			Irrigation	2
451	do	do	B-4	?1894	Bored, 7-inch	38	38	96			Not raised			Not used	
452	do	do	B-3	1904	Bored, 4-inch	39	39	90	33	64	Artesian			Irrigation	Small.
453	do	do	B-4		Bored, 2-inch	38	38	86			do			Irrigation; stock	Small.
454	C. W. Fox	do	B-3			38	38	90	33	64	Hand			Domestic	
456	R. B. Wardlow	do	B-3	1898	Bored, 2-inch	39	39	100	31	64	Artesian, hand			do	
457	do	do	B-3	1902	do	40	40	90	32	63	Artesian			Irrigation; stock	2
458	A. McChristian	do	B-3	1899	do	39	39	106	32	63	do			Domestic; irrigation.	3
459	do	do	C-4	1902	do	38	38	93			do			Irrigation	3
460	do	do	C-3		do	38	38	86	31	64	do			do	1
461	do	do	C-3	1901	do	39	39	100	31	64	do			do	1
462	do	do	B, C-4	?1898	do	38	38	98	31	63	do			do	2
463	R. B. Wardlow	do	B-4	1904	do	37	37	90	30	64	do			Not used	Small.
464	do	do	C-4	1904	do	37	37	96			do			Stock	4
465	do	do	C-4	1898	do	37	37	92			do			Irrigation	3
466	do	do	C-4	1902	do	37	37	90	32	64	do			do	2
468	W. F. Taylor	do	C-4		do	37	37	93	32	65	do			Domestic; stock	1
469	Sam Talbert	do	B-4	1904	do	37	37	90	32	64	do			Domestic	4
470	do	do	B-4	1898	Bored, 4-inch	37	37	90	31	65	do			Domestic; stock	
471	do	do	B-4	1903	Bored, 7-inch	37	37	120	31	64	do			Irrigation	5

Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
472	J. Alton	Las Bolsas	C-4		Bored, 4-inch	36	36		34	64	Artesian			Domestic; irrigation.	1
473	O. P. Wood	do	C-4	?1900	Bored, 2-inch	35	35		33	64	do			Domestic	
474	do	do	C-4	1901	do	34	34	90			do			Irrigation	
475	T. J. Lewis	do	B-4	1904	Bored, 7-inch	38	38	131	32	64	do			do	24
476	do	do	B-4	1903	do	38	38	120			do			do	9
477	do	do	B-4		Bored, 4-inch	36	36		32	64	do			do	5
478	John H. Pope	do	B-5	1898	Bored, 7-inch	35	35	120	30	65	do			Domestic; irrigation.	12
479	Geo. Edwards	do	C-5	1897	Bored, 2-inch	35	35	80	30	65	do			Domestic	1
480	Geo. Bradley	do	B, C-5		Bored, 7-inch	35	35		30	65	do			Domestic; irrigation.	7
481	T. V. Talbert	do	B-4, 5	1901	do	38	38	100	30	63	do			Irrigation	7
482	J. E. McGowen	do	B-4		Bored, 2-inch	40	40	97	31	63	do			Domestic; stock	2
483	do	do	B-4	1904	Bored, 7-inch	40	40	130		63	do			Irrigation	14
484	R. Courreges	do	B-4	1900	do	45	45	210			do			do	12
485	L. Wells	do	B-3	1901	Bored, 4-inch	38	38	100	31	64	do			Domestic; irrigation.	8
489	R. Courreges	do	B-4	1897	Bored, 8-inch	50	33	148	31	65	Wind			Domestic; stock	
490	do	do	B-4	1898	Bored, 7-inch	55	33	149			do			Stock	
491	A. J. Young	do	A-4	1903	Bored, 2-inch	35	35	288			Artesian			Irrigation	6
492	do	do	A-4	1903	do	35	35	258			do			Not used	
493	S. J. Strakes	do	A-4	1898	Bored, 3-inch	45		?100			Hand			Domestic	
494	H. H. Lewis	do	A-3, 4	1901	Bored, 7-inch	30	30	318			Artesian			Irrigation	6

496	A. C. Shears	do	A-3	1896	Bored, 2-inch	35	23	153			Wind			Domestic; stock	
497	W. J. Horton	do	A-3	1902	Bored, 6-inch	30	30	?400			Artesian			Irrigation	11
498	A. A. Fisk	do	A-3		Bored, 2-inch	35		160			Hand			Domestic	
499	J. T. Stockton	do	A-3	1904	Bored, 10-inch	30	30	360			Artesian			Irrigation	
500	John Blalock	do	A-3		Bored, 7-inch	30	30	346+			do			do	6
501	S. W. Elliott	do	A-3	1897	Bored, 2-inch	33	33	162			do			do	4
502	do	do	A-3	1897	do	35	35	162			Hand			Domestic; stock	
503	do	do	A-3	1898	Bored, 3-inch	30	30	147			Artesian			Irrigation	
504	W. M. Fowler	do	A-3	a1897	Bored, 2-inch	35	35	147			Siphoned			do	
505	do	do	A-3, 4	1897	do	40	35	149			Hand			Domestic; stock	
506	S. J. Strakes	do	A-3	1897	Bored, 3-inch	30	30	?100			Artesian			Irrigation	
508	A. C. Adams	do	A-4	1900	Bored, 7-inch	40	40	365			do			do	9
509	S. J. Strakes	do	A-4	1897	Bored, 4-inch	45	30	121			Hand			Domestic	
510	R. Courreges	do	B-4	1898	Bored, 2-inch	40	40	84	31	64	Artesian			Irrigation	1
511	T. V. Talbert	do	B-4		Bored, 7-inch	38	38	?120	37	64	do			do	
512	J. W. Fairchild	do	B-4	1902	Bored, 2-inch	38	38	90	31	64	do			Domestic	2
513	do	do	B-4	?1874	Bored, 7-inch	40	40	90			do			Irrigation	7
515	W. R. Fowler	do	B-4	?1900	do	37	37	115			do			do	4
516	R. O. Wells	do	B-4	1902	Bored, 2-inch	38	38	100	31	64	do			Domestic; stock	Small.
517	Sam Dungan	do	B-4		Bored, 3-inch	40	40	?100	31		do			Domestic; irrigation.	
518	W. R. Fowler	do	B-4	1903	Bored, 2-inch	38	38	75			do			Irrigation	4
519	C. F. Ward	do	B-4	1903	Bored, 7-inch	38	38	104			do			Domestic; irrigation,	22
520	do	do	B-4		do	38	38	108			do			Irrigation	17
525	Henry Talbert	do	B-5	1902	do	35	35	?120	32		do			do	16
526	Dan Rhodes	Santa Ana	F-1		Bored, 6-inch	73	63	?100	44		Wind			Domestic; stock	
527	Mr. Dearendoff	do	F-1	?1901	Driven, 1¼-inch	75	63		108		do			Irrigation	
527a	do	do	F-1	?1901	Bored, 7-inch	75	63	100			do			do	
528	Chinese Market Gardeners.	do	F-1		do	80	62	160	38		do			Domestic; stock	
529	J. S. Cardell	do	F-1	?1889	Bored, 4-inch	63	52	80	47		do			Domestic	
530	C. C. Rubottom	do	F-1		Bored, 3½-inch	60	48	60	37		do			Domestic; stock	
531	S. D. Butler	do	F-1	1898	Bored, 4-inch	65	54	83	46		do			Irrigation	
532	Henry Lucas	do	F-1	1887		60	51	100	44	65	Hand			Domestic	

Wells in the Santa Ana quadrangle—Continued.

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						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
533	Geo. Meganity	Santa Ana	F-1	1888	Bored, 4-inch	58	48	83	47	67	Hand			Domestic	
534	S. D. Butler	do	F-1	1888	do	58	47	126			Wind			Irrigation	
535	W. W. Wilmot	do	F-1		do	45		68			Hand			Not used	
536	Mrs. M. R. Baley	do	F-1		do	60	48	90	41		Wind			Domestic; irrigation.	
537	V. E. Pierson	do	F-1	1903	Bored, 10-inch	50	40	104	35	66	Gas			Irrigation	†0.8
538	do	do	F-1	?1894	Bored, 4-inch	58	49	68			Hand			Domestic	
539	do	do	F-1	?1884	do	48	37	80			Not raised			Not used	
540	S. Trivoli	do	F-1	1898		55	49		47	65	Wind			Stock	
543	E. C. Johnson	do	F-1	?1899	Bored, 4-inch	73	72	?56	51	66	do			Domestic; stock	
544	A. L. Carter	do	F-1	?1884	do	80			52		Hand			Domestic; irrigation.	
545	A. A. Arms	do	F-1	1897		85	81	?64	50	67	Wind			Domestic; stock	
546	Frank Talbert	do	F-1	1902	Bored, 7-inch	75	72	?50	47	66	do			Domestic; irrigation; stock.	
547	W. F. McClintock	do	F-1	1899	Bored, 4-inch	73	71	?60	52	64	Hand			Domestic; stock	
548	do	do	F-1		Bored, 6-inch	75	71	?60			Flows into reservoir.			Stock	
549	do	do	F-1		Bored, 4-inch	75	71	?60			do			do	
550	W. H. Bates	do	G-1		Bored, 7-inch	85	77	?80	51		Wind			Domestic; irrigation; stock.	
551	L. T. Oswald	do	G-1	1904	do	85	77	52	120		Hand	$52.00		do	
552	Samuel Ross	do	G-1	1903	Bored, 9½-inch (3)	85	73	62			Gas	321.00	$1,200.00	Irrigation	†80
553	Robert McFadden	do	G-1		Bored, 7-inch									Domestic; stock	

554	Samuel Ross	do	G-1	1902	do	88	78	152			Not raised			Not used			
556	H. S. Pankey	do	G-1	1890	do	75		66	48		Wind						
557	do	do	G-1	1890	do	75	66	49	42		Hand			Domestic			
558	do	do	G-1	1901	do	75	57	65			Gas	200.00		Irrigation			
559	do	do	G-1	1901	Bored, 10-inch	75	57	65			do	200.00		do			†80
560	do	do	G-1	1902	do	75	57	65			do	200.00		do			
561	Santa Ana Gun Club	do	F-1		Bored, 4-inch	74	74		48		Artesian			Stock			
562	Mr. Towle	do	G-1			77			86		Hand			do			
563	L. Rees	do	G-1	1900	Bored, 6-inch	77	57	66	41		do			Domestic; stock			
564	do	do	G-1	1878	Bored, 7-inch	75	64	312			Not raised			Not used			
565	Garensy Estate	do	G-1		do	90		312			do			do			
566	Samuel Ross	do	G-1	1903	do	76	66	80+	50		Wind	100.00	150.00	Domestic; stock			
567	do	do	G-1	1884	do	76	66	80+			Hand			Not used			
568	do	do	G-1	1884	Bored, 6-inch	83	76	80+			Not raised			do			
569	Mr. Melvin	do	G-1	1900	Bored, 4-inch	77		100	49	64	Wind			Domestic; irrigation.			
570	Mrs. J. Hassheider	do	G-1		Bored, 7-inch	75	47	61	50	67	do			Domestic; stock			
571	Dan. Rhodes	do	G-1		do	95	65	104	44	67	do			do			
572	Mrs. Mary Hawley	do	G-1	1903	Bored, 4-inch	95		80	45	67	Hand	65.00		do			
573	J. T. Wilson	do	G-1		Bored, 7-inch	93			49		Hand, gas			do			
574	Geo. Wandsheer	do	G-1	?1894	do	100	82	51	44		Wind, hand			do			
575	Mr. Buhart	do	G-1	1903	Bored, 12-inch	103	86	62	62	67	Wind			do			
576	A. E. Bird	do	G-1	1902	Bored, 7-inch	103		?68	47		do	68.00	+135.00	Domestic; irrigation; stock.			
577	R. Best	do	G-1		do	103	80	53	55		do			do			
578	M. Erreca	do	G-1		do	104			49		do			Domestic; stock			
579	U. L. Wilhite	do	G-1	1884	do	115	90	65	44		Hand			do			
580	John Manthei	do	G-1		do	92		?85	54		Wind			do			
581	C. M. Young	do	G-1		Bored, 6-inch	120	95	55	90		do			Domestic; irrigation; stock.			
583	T. M. Turner	do	G-1	1890	Bored, 7-inch	115		55	56	67	do			Domestic; stock			
584	Theo. Oswald	do	G-1	1888	do	113	100	54	53	66	do		+335.00	do			
585	Mr. Shelton	do	G-1	1891	do	102	90	56	52		do	50.00	150.00				
586	V. R. Casey	do	G-1		do	100	81	55	51	66	do			Domestic; stock			
587	Wm. Hounsom	do	G-1		Bored, 4-inch	105			51	66	do		+120.00	Domestic; irrigation; stock.			

Wells in the Santa Ana quadrangle—Continued.

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						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
590	J. G. Bailey	Santa Ana	H-1	1876	Dug, 10 feet; bored, 7-inch, 301 feet	135		311	41		Wind			Domestic; stock	
591	Santa Ana Steam Laundry Company.	do	H-1	1901	Bored, 7-inch	132	96	?86	51		Steam		$600.00	Domestic	
592	Santa Ana city waterworks.	do	G, H-1	1899	Bored, 10-inch	100	78	350	42	67	do			do	
593	do	do	G-1	1893	Bored, 7-inch	100	78	350	45	67	do			do	
594	do	do	G-1	1903	Bored, 12-inch	100	78	350	34	67	do	$775.40		do	166
595	do	do	G-1	1903	do	100	78	387			do	775.40		do	
596	do	do	G-1	1901	do	102	80	351	43	67	do	950.00		do	
597	L. M. Edwards	do	G-1		Bored, 7-inch	100	79	60	46		Wind			Domestic; stock	
598	Robert Show	do	G-1			105			67		Hand			do	
599	Wm. Briggs	do	G-1		Bored, 7-inch	100			62		do			do	
600	P. White	do	G-1		do	98			52		Wind			do	
601	F. J. Heil	do	G-1	1902	do	85	60	72			Not raised	87.00		Not used	
602	do	do	G-1	1893	do	80		76	49		Wind			Domestic; stock	
603	W. A. Penrod	do	G-1	1899	do	85	74	48	50		Hand			do	
604	Mrs. M. Funk	do	G-1	1888	Bored, 6-inch	85	72	57	60		do			do	
605	Chas. Silkwood	do	G-1		Bored, 4-inch	85			52		do			do	
606	Mrs. S. A. Sexton	do	G-1		Bored, 7-inch	100	82	56	48		do			do	
607	F. M. Gist	do	H-1	1882	do	105	88	110	41	67	Wind			Stock	
608	N. Palmer	do	H-1	1875		125		300+	42					Domestic; irrigation; stock.	

609	Mrs. L. Moye	do	H-1	1890	Bored, 7-inch	130	98	700	10					Domestic; stock	
610	Mr. Clinton	do	H-1		do	130			66		do			do	
611	J. H. Bruner	do	H-1	1877	do	130	100	58			do			Not used	
612	S. T. Miller	do	H-1	1886		136		40	57		do			Domestic; stock	
613	Ahlers & East	do	I-1	1904	Bored, 10-inch	138	96	336	36	71	Steam	672.00		Domestic	
614	P. Blanco	do	I-1			130			62		Hand			do	
615	D. Halladay	do	H-1	1882	Bored, 7-inch, 150 feet; 6-inch, 145 feet.	130	99	295			Wind			Not used	
616	Mrs. M. K. Beckett	do	H-1	1888		130		?160	52		do			Domestic; stock	
617	W. S. Rose	do	I-1	1892		133	87	57	64		do			do	
618	B. F. Nimms	do	I-1	?1893	Bored, 7-inch	33	98	42	60		Hand			do	
619	V. Earhart	do	I-1	1899	do	120	101	36	83		Wind			do	
620	M. D. Halladay	do	H-1	1886	do	130	110	279	48		do			do	
621	R. J. Blee	do	H-1	1888	Bored, 9¼-inch	127	112	?325	46		do			Stock; domestic	
622	Robert Talbert	do	H-1	1888	Bored, 7-inch	125	100	52	57		do			Domestic	
623	F. E. Bangs	do	H-1	1901	do	120	100	120	48		do	150.00	150.00	Domestic; stock	
624	D. Halladay	do	H-1	1900	Bored, 10-inch	120	98	450			Not raised	800.00		Not used	
625	L. F. & A. S. Holbrook	do	H-1, 2		Bored, 6-inch	116	100	58	65		Wind			Domestic; stock	
626	D. V. Pritchard	do	I-2	1892	Bored, 7-inch	112	100	42	90		Hand			Domestic	
627	do	do	I-2	1900	do	115	100	105			Not raised			Not used	
628	Chas. Andres	do	H-2	?1876	do	100		40	74		Hand			Domestic; stock	
629	Mr. Burch	do	H-1, 2	1901	do	110	92	63	60		do			Not used	
630	H. A. Skiles	do	H-1, 2	1898	do	110	92	30	106		do	25.00		Domestic; stock	
631	L. B. Skiles	do	H-1	1898	do	10	92	30	106		Wind	25.00		Stock; domestic	
632	W. H. Conder	do	H-1	1900	do	10		?100	49		do			Domestic; stock	
633	E. G. Huntington	do	H-1		Bored, 6-inch		93	60	48	68	do		40.00	do	
634	W. H. Ivans	do	H-2	?1886	Bored, 7-inch	105		?60	61		Hand			do	
635	Stephen Ross	do	H-2	1894	Bored, 6-inch	100	98	368	32		Wind			do	
636	Mr. Lancaster	do	H-2		Bored, 7-inch	98			36		Hand			do	
637	Mr. Lewis	do	G, H-2		Dug, 4 by 4 foot	85	75	12			Wind			Stock	
638	J. L. Barger	do	G-2		Bored, 4-inch	85	83	?270	42		Hand			Domestic; stock	
639	do	do	G-2		Bored, 7-inch	85	76	83			Not raised			Not used	
640	Chas. Anderson	do	G-2	?1894	Bored, 6-inch	80	71	60	35		Wind		+119.00	Domestic; stock	
641	A. C. Stanley	do	G-2	1902	Bored, 7-inch	87		91			do	91.00	40.00	do	
642	Mrs. Brown	do	G-1		do	87	79	115	39		Hand			Stock	

Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
643	Morse & Randal	Santa Ana	G-1	1902	Bored, 7-inch	88	77	340	37	....	Hand	$488.37	.....	Stock	.....
644	....do	....do	G-1	1904	Bored, 12-inch	88	77	270	....	....	Not raised	321.00	.....	Not used	.....
645	J. A. Buckingham	....do	G-1	?1875	Bored, 7-inch	95	80	39	57	68	Wind	.....	.....	Domestic; stock	.....
646	Frank Clapp	....do	H-1	1890	....do	100	82	88	56	....	Hand	.....	.....	Domestic	.....
647	James McFadden	....do	H-2	1889	....do	95	85	260	29	....	Wind	.....	.....	Domestic; stock	.....
648	....do	....do	H-2	1904	Bored, 10-inch	95	85	270	....	....	Installing pumping plant.	.....	.....	.....	.....
649	....do	....do	H-2	1902	....do	95	85	270	....	....	....do	.....	.....	.....	.....
650	....do	....do	H-2	1892	Bored, 7-inch	80	80	250	34	....	Artesian	.....	.....	Stock	.....
651	....do	....do	H-3	1870	Bored, 4-inch	58	58	50	42	69	....do	.....	.....	Domestic; stock	.....
652	....do	....do	H-3	1901	Bored, 7-inch	58	58	400+	42	70	....do	.....	.....	....do	.....
653	....do	....do	H-3	?1901	Hydraulic, 2-inch	58	58	264	37	71	....do	.....	.....	.....	.....
654	....do	....do	G-3	1899	Bored, 7-inch	53	53	260	37	70	....do	.....	.....	Irrigation	29
655	....do	....do	G-3	1899	....do	51	51	260	....	....	....do	.....	.....	Irrigation; stock	8
656	....do	....do	H-3	.....	Bored, 10-inch	65	65	64	49	64	....do	.....	.....	Stock	.....
657	W. W. Fisher	....do	H-3	.....	.....	60	60	260+	42	68	....do	.....	.....	Irrigation	.....
658	Delhi school district	....do	H-3	1903	Hydraulic, 2-inch	62	62	224	44	68	....do	91.00	.....	Domestic	.....
659	James McFadden	....do	G-4	1899	Bored, 7-inch	42	42	360	....	....	....do	.....	.....	Stock	.....
660	....do	....do	H-3	1888	....do	48	48	80	48	66	....do	.....	.....	....do	Small.
661	....do	....do	H-4	1888	....do	44	44	60	....	....	....do	.....	.....	....do	.....
662	....do	....do	G-5	1904	Bored, 4-inch	48	48	.....	44	70	....do	.....	.....	....do	.....

663	Henry Yount	do	H-2	1899	Bored, 7-inch	90	84	344			Gas	500.00	$600.00	Domestic; irrigation; stock.	
664	J. D. Carter	do	H-2	1898		72	54	21	57		Hand			Domestic; stock	
665	L. H. Price	do	H-3	1896	Bored, 7-inch	68	62	380+	44		Gas			do	
666	do	do	H-3	1888	Bored, 4-inch	65	65	380+	40		Artesian			Irrigation	†27
667	C. E. Buell	do	H-3		Hydraulic, 2-inch	68	68	?260	41	70	do			Domestic; irrigation; stock.	
668	do	do	H-3		Hydraulic, 3-inch	67	67	260+	41		do			Irrigation	17
669	G. W. Stuart	do	H-3	1902	Bored, 7-inch	65	65	63	44		Hand	63.00		Domestic; stock	
670	do	do	H-3	1903	Bored, 3-inch	65	65	265	43	70	Artesian			Domestic; irrigation; stock.	5
673	Mr. Russell	do	H-3	1900	Hydraulic, 2-inch	58	58	263	42		do			Domestic; stock	
674	W. W. Fisher	do	H-3		do	58	58	260+	41	69	do			Domestic	
675	do	do	H-3		do	55	55	27	49	68	do			Stock	Small.
676	W. L. Neill	do	H-3		Bored, 7-inch	55	55	27	49	68	do			do	
677	Delhi school district	do	H-3		Bored, 4-inch	62	62				do			Not used	
678	Henry Meason	do	H-3	?1884	Bored, 5-inch	63	63		40	68	do			Domestic; stock	
679	do	do	H-3	1899	Hydraulic, 2-inch	62	62	180	34	68	do			do	
680	do	do	H-3	1898	do	60	60	?180			do				
681	Alfred Williams	do	I-3		Bored, 7-inch	64	64	200			do			Not used	
682	do	do	I-3		do	61	64	196	37	69	do			Irrigation	
683	O. B. and C. C. Bridgeford.	do	I-3	1892	Bored, 4-inch	65	63	53	51		Hand			Domestic; stock	
684	J. L. Allen	do	H-3		Bored, 5-inch	58	58	?200	39		Artesian			Stock	Small.
685	do	do	H-3			54	50	?150	44		Hand			Domestic; stock	
686	L. W. Allen	do	H-3	1904	Hydraulic, 3-inch	57	57				Artesian			Irrigation	
687	G. Mall	do	I-3	1903	Hydraulic, 2-inch	54	54	?210	37	70	do	85.00		Domestic; irrigation; stock.	
688	J. W. Robertson	do	I-3	1904	Bored, 2-inch	55	55	212	38	70	do	85.00		Domestic; stock	
689	J. P. Manning	do	H-4	1900	Bored, 4-inch	50	50	206+	40	72	do			do	
690	G. W. Gynn	do	H-3	1897	do	53	53	?209	38	71	do			Stock	
691	do	do	H-3	1901	Hydraulic 3-inch	53	53	212	40		do	100.00		Domestic; stock	3
692	do	do	H-3	1902	Bored, 7-inch	53	53	220	41	73	do	250.00		Irrigation	7
693	J. R. McCarter	do	H-3		Hydraulic, 2-inch	54	54	200+	43	72	do			do	
694	J. J. Ryan	do	H-3	1903	Driven, 2-inch	53	53	239			do			do	
695	do	do	H-3		Bored, 4-inch	57	57	40	52	72	Hand			Domestic; stock	
696	G. Mall	do	H-3	1904	Hydraulic, 2-inch	53	53	239	42		Artesian	127.00		Irrigation	5

Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
698	Mr. Feathero	Santa Ana	H-4		Bored, 7-inch	48	48	.....	45	67	Artesian	.....	.....	Stock	.....
699	C. A. Leighton	do	H-4		Hydraulic, 2-inch	52	52	200+	42	69	do	.....	.....	Irrigation	4
701	do	do	H-4		do	45	45	35	50	.....	do	.....	.....	Domestic; stock	.....
702	Mr. Quick	do	H-4	1900	Bored, 7-inch	50	50	214	44	69	do	.....	.....	Irrrigation	.....
703	D. Boyd	do	H-4	1904	Hydraulic, 3-inch	45	45	196	41	70	do	$108.00	.....	do	11
704	do	do	H-4	1897	Hydraulic, 2 inch	45	45	194	34	72	do	105.00	.....	Irrigation; stock	3
705	do	do	H-4	1886	Bored, 4-inch	43	43	132	42	68	do	.....	.....	Domestic	.....
706	F. N. Morse	do	I-4	.....	Hydraulic, 4-inch	53	53	218	41	70	do	.....	.....	Domestic; stock	4
707	do	do	I-3	1904	Bored, 10-inch	44	44	490	39	73	do	1,055.00	.....	Irrigation	10
708	J. S. Fox	do	I-3	1878	Bored, 5-inch	60	60	200	36	71	do	.....	.....	Domestic; irrigation; stock.	3
709	Mrs. Huntzinger	do	I-3	1884	Bored, 3-inch, inside of 7-inch.	65	65	.....	37	68	do	.....	.....	Domestic; stock	.....
710	Chas. H. Wilbur	do	I-3	1903	Hydraulic, 2-inch	70	70	264	33	71	do	150.00	.....	Domestic; irrigation; stock.	2
711	do	do	I-3	1899	Bored, 7-inch	75	75	331	.....	.....	do	400.00	.....	Irrigation	4
712	W. S. Hall	do	I-3	1903	Hydraulic, 3-inch	73	73	250	38	68	do	.....	.....	Domestic; stock	2
713	do	do	I-3	1887	Bored, 7-inch	73	70	34	46	67	Hand	.....	.....	Not used	.....
714	Frank Thomas	do	I-3	1890	Bored, 4-inch	79	79	196	38	70	Artesian	.....	.....	Domestic; stock	4
715	J. S. [illegible]	do	I-3	1904	Bored, 10-inch	67	67	284	37	70	do	500.00	.....	Irrigation	.....
716	do	do	I-3	?1876	Bored, 4-inch, inside of 7-inch.	67	67	250	37	...	do	.....	.....	Stock	.....
717	do	do	I-3	1900	Hydraulic, 3-inch	67	67	220	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
718	Irvine Rancho Co	do	I-3	1904	Hydraulic, 3-inch	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	do	130.00	.....	Domestic; stock	.....

719	J. A. Wilkes	do	I-3	1899	do								Stock	42
720	do	do	I-2	1892	Bored, 7-inch	85	85	185	88	71	Gas		Irrigation	
721	Alton Warner	do	I-2		Hydraulic, 3-inch	85	83		42		Wind, horse-power.		Stock	
722	T. F. Brooks	do	I-2			90			54		Hand		Domestic	
723	J. C. Thomas	do	I-2	1902	Bored, 7-inch	98	93	200+			Not raised		Not used	
724	T. J. McCarter	do	I-2	1902	do	105		90+	51		Wind		Domestic; stock	
725	W. S. Ritchey	do	I-1	1870		110	98	200+	44		do		do	
726	B. S. Kerns	do	G-1		Bored, 6-inch	75	64	59	44		do		do	
727	Mathews & Travis	do	G-1	?1887	Bored, 7-inch	80	69	18	51		do		do	
728	P. M. Conkle	do	G-1	1903	Bored, 10-inch	76		98	48		Wind, hand		do	
729	T. P. Page	do	G-1	1903	Bored, 7-inch	76	68	69	51		Wind	72.00	+$295.00 do	
730	T. McPearson	do	G-1	1903	do	71	66	71	49		Hand		do	
731	J. S. Kohler	do	G-1		do	72	64	59	52		do		do	
732	B. W. Walker	do	G-1	1900	do	75	61	375	160		Gas	600.00	950.00 Irrigation	†40
733	C. A. Barton	do	G-1	1896		74		?85	46		Wind	80.00	Domestic; stock	
734	J. H. Parsons	do	G-2	1902	Bored, 7-inch	73		87	55	68	do		do	
735	Walter L. Neill	do	G-2		Bored, 4-inch	68	62	152	48	68	Hand		Stock	
736	do	do	G-2		Bored, 7-inch	68	65	64	54		do		Domestic; stock	
737	Fair Association	do	G-2		do	70			37		Wind		Roads	
738	R. J. Blee	do	G-2	?1900	do	75	75	355			Artesian	527.00	Stock	†35
739	Fair Association	do	G-2		do	64			43	68	Wind		Roads	
740	Mrs. S. E. Blake	do	G-2	?1898	do	63	63	?390	43	70	Artesian		Irrigation	
741	do	do	G-2	1897	do	62	62	95	40		Wind		Domestic; stock	
742	G. W. Bissett	do	G-2	?1884	Bored, 5-inch	63	63	?72	33	69	Artesian		Domestic; irrigation.	
743	do	do	G-2	?1884	Bored, 4-inch	65	65	?62	41	68	do		Domestic; stock	
744	B. W. Walker	do	G-2	1904	Bored, 9½-inch (2)	70	69	114	41		Gas	800.00	Irrigation	
745	do	do	G-2		Bored, 4-inch	70	70		48	67	Hand		Domestic; stock	
746	C. C. Edingeir	do	G-2		do	73	72	54	52		do		Domestic	
747	do	do	G-2			74	74	56	47		Hand, artesian		Stock	
748	David Fickas	do	G-2		Dug, 5 by 5 foot	66	64	3	48	66	Hand			
749	G. H. Judd	do	G-2	1884	Bored, 4-inch	60	60	?130	48	68	Artesian		Domestic; stock	
750	do	do	G-2	1888	Bored, 4-inch, inside of 9-inch.	60	60	91	46	68	do		Domestic; irrigation.	
751	W. C. Ten Eyck	do	G-2	1898	Bored, 4-inch	57	57	96	48	68	do		do	

Wells in the Santa Ana quadrangle—Continued.

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						Feet.	*Feet.*	*Feet.*		°F.					*Miner's inches.*
752	W. C. Ten Eyck	Santa Ana	G-2	1892	Bored, 5-inch	57	57	75	44	67	Artesian			Domestic; stock	
753	P. Stefanazzi	do	G-2	1879	Bored, 4-inch	56	56	67	42	67	do			do	
754	J. F. Cavanaugh	do	G-2	1881	do	55	55	55	46	66	do			do	
755	do	do	G-2	1892	do	53	53	69	43		do			Stock	4
756	do	do	G-2	1902	Hydraulic, 2-inch	53	53	75	44	66	do	$40.00		Irrigation	Small.
757	Joe Nusbaumer	do	G-2	?1892	Bored, 4-inch	58	58	?88	42		Wind	75.00		Domestic; stock	
758	do	do	G-2	1890	Bored, 7-inch	60	60	90+			Artesian			Irrigation	
759	do	do	G-2	1902	Hydraulic, 3-inch	61	61	?336	33	67	do	240.00		do	5
760	W. C. Long	do	G-2	1876	Hydraulic, 3½-inch.	56	56	75	46	65	do			Domestic	
761	do	do	G-2	1902	Bored, 4-inch	55	55	377	29	65	do	275.00		Irrigation; stock	
762	do	do	G-2	1898	do	55	55	102	44	66	do			Irrigation	
763	do	do	G-2	1884	Bored, 2-inch, inside of 4-inch.	56	56	75	40	65	do			do	
764	do	do	G-2	1879	Bored, 4-inch	58	58	?150	43		do			do	
765	do	do	G-2	1886	Bored, 2-inch, inside of 4-inch.	58	58	114	47		do			do	
766	T. W. Clark	do	F-2		Bored, 4-inch, inside of 7-inch.	53	53		54	67	do			do	
767	F. W. Clark	do	F-2		Bored, 7-inch	50	50	?110	51	63	do			do	
768	J. W. Harmon	do	F-2	1879	Bored, 4-inch, inside of 7-inch.	53	53	98	37		Hand			Domestic; stock	
769	do	do	F-2	1879	Bored, 4-inch	52	52	85	41		do			Stock	
770	do	do	F-2	1878	Hydraulic, 2-inch	55	55	61	49	68	[illegible]			[illegible]	

771	.....do	.....do	F-2	1904	Bored, 9½-inch...	56	52	80	.....	.....	Gas	.....	.....	.....	.....
772	.....do	.....do	F-2	1878	Bored, 6-inch....	52	52	78	.....	.....	.....do	.....	.....	Irrigation	.....
773	.....do	.....do	F-2	1878	Bored, 10-inch...	52	52	78	.....	.....	.....do	.....	.....	.....do	.....
774	.....do	.....do	F-2	.....	Bored, 6-inch....	50	48	190	.....	.....	Hand	.....	.....	Not used	.....
775	J. T. Raitt	.....do	F-2	.....	Bored, 7-inch....	48	42	201	.....	.....	Not raised	.....	.....	.....do	.....
776	.....do	.....do	F-1	1904	Bored, 10-inch...	52	50	110	40	....	Steam	.....	.....	Domestic; stock	.....
777	.....do	.....do	F-1	1900	.....do	52	50	113	40	....	.....do	.....	.....	.....do	.....
778	.....do	.....do	F-1	.....	Bored, 7-inch, inside of 10-inch.	52	50	98	40	....	.....do	.....	.....	.....do	.....
779	.....do	.....do	F-1	1901	Bored, 10-inch...	52	50	110	40	....	.....do	.....	.....	.....do	.....
780	J. A. Timmons	.....do	F-1	1888	Bored, 4-inch....	58	54	110	37	....	Hand	.....	.....	Domestic	.....
781	.....do	.....do	F-1	1901	Bored, 9-inch....	61	59	112	.....	.....	Not raised	.....	.....	Not used	.....
782	.....do	.....do	F-1	1901	Hydraulic, 2-inch	62	60	112	.....	.....	.....do	.....	.....	.....do	.....
783	Joseph Thacker	.....do	F-1	.....	Bored, 10-inch...	55	.....	.....	42	....	Hand	.....	.....	Domestic; stock	.....
784	David McCarty	.....do	F-1	.....	Bored, 4-inch....	57	.....	.....	48	....	.....do	.....	.....	.....do	.....
785	Oliver Litten	.....do	F-1	1887	Bored, 6-inch....	60	.....	?110	36	69	.....do	.....	.....	.....do	.....
786	.....do	.....do	F-1	?1883	Bored, 7-inch....	60	57	?110	43	66	Wind	.....	.....	Stock	.....
787	Geo. M. Stanton	.....do	F-1	?1883	Bored, 6-inch....	55	49	350	37	.....	.....do	.....	.....	Irrigation; stock	.....
788	.....do	.....do	F-1	?1883	Bored, 4-inch....	57	57	75+	37	....	Hand	.....	.....	Domestic	.....
789	M. A. Simco	.....do	F-1	1891	.....do	57	55	?95	42	66	Wind	.....	.....	Domestic; stock	.....
790	V. H. Duncan	.....do	F-2	.....	.....do	50	50	80	43	65	Artesian	.....	.....	.....do	.....
791	.....do	.....do	F-2	.....	Hydraulic, 2-inch	48	48	69	41	65	.....do	.....	.....	Stock	1
792	.....do	.....do	F-2	.....	Hydraulic, 1½-inch.	51	51	.....	38	....	.....do	.....	.....	.....do	.....
793	R. M. Dungan	.....do	F-2	.....	Bored, 4-inch....	46	45	138	38	....	Hand	.....	.....	Domestic; stock	.....
794	.....do	.....do	F-3	.....	Bored, 6-inch....	47	47	85	39	....	Artesian	.....	.....	Stock	.....
795	Mr. Boland	.....do	E-2	1874	.....do	47	47	?450	31	66	.....do	.....	.....	Domestic; stock	35
796	V. H. Duncan	.....do	F-2	.....	Bored, 4-inch, inside of 6-inch.	45	43	56	.....	.....	Not raised	.....	.....	Not used	.....
797	S. P. Boland	.....do	F-2	1882	Bored, 4-inch....	40	40	90	37	65	Artesian	.....	.....	Domestic	.....
798	.....do	.....do	F-2	1902	Bored, 7-inch....	43	43	116	39	65	.....do	.....	.....	Irrigation	4
799	.....do	.....do	F-2	1878	Bored, 2-inch, inside of 4-inch.	43	43	94	38	65	.....do	.....	.....	.....do	.....
800	J. W. Harmon	.....do	F-2	.....	.....	55	52	95	35	....	.....	.....	.....	.....	.....
801	Elmer Lipton	.....do	F-2	.....	Bored, 7-inch....	52	52	61	47	69	Artesian	.....	.....	Domestic; stock	.....
802	Mrs. McCarmack	.....do	F-2	.....	Bored, 2-inch....	52	52	.....	.....	.....	.....do	.....	.....	Domestic	.....

Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°					*Miner's inches.*
803	Phil Rutherford	Santa Ana	F-2		Bored, 4-inch	47	47		43	65	Artesian			Domestic; irrigation.	
804	do	do	F-2		Bored, 5-inch, inside of 7-inch.	46	46	200+	42	66	do			Irrigation	
805	do	do	F-2		Bored, 7-inch	48	48	79	43	65	do			do	
806	Mr. Harvey	do	F, G-2, 3		do	48	48	200+	33	67	do			do	
807	W. A. Bear	do	F-3	?1879	Bored, 3-inch	43	43	85	37	66	do			Domestic	
808	Jos. Nusbaumer	do	F-3		Bored, 4-inch	44	41	200+	37	66	do			Stock	
809	F. P. Bowland	do	F-3	?1880	Bored, 8-inch	40	40		42		do			Domestic; irrigation.	
810	do	do	F-3	?1891	Bored, 4-inch	38			38	65					
811	do	do	F-3		do	38	38	60			Hand			Not used	
812	R. P. Selvidge	do	F-3		do	38	38	90+	39		Gas			Irrigation	
813	do	do	F-3	1901	Bored, 7-inch	38	38	?158	37	65	do			do	
814	E. M. Peet	do	F-3		Bored, 6-inch	40	40	?75	39	66	Artesian			Domestic; stock	
815	R. P. Selvidge	do	F-3		Hydraulic, 3-inch	38	38		36	65	do			do	
816	Mr. Raibel	do	F-3		Bored, 4-inch	38	38	62	35	66	do				Small.
817	Mrs. Raibel	do	F-3		Bored, 3-inch	38	38		37	65	do			Stock	
818	T. C. Williams	do	F-3	?1874	Hydraulic, 3-inch	40	40	60	36	65	do			Domestic; stock	
819	do	do	F-3		do	43	43	59	37	66	do			Stock	Small.
820	do	do	F-3		Bored, 7-inch	43	43	200+	36	68	do			Irrigation	
821	do	do	F-3		Bored, 6-inch	42	42		35	66	do			Irrigation; stock	
822	do	do	F-3		Bored, 7-inch	42	42	108	32	66	do				

823	Mrs. S. L. Rogers	do	G-2	?1880	Bored, 3-inch, inside of 7-inch.	58	58	65	43	66	do			Domestic; irrigation.		1
824	Martha M. Smith	do	G-2		Hydraulic, 3-inch	57	57	60	44	66	do			do		
825	H. W. Rulison	do	G-2	1892	Bored, 3-inch	55	55	56	43		do	$75.00				1
826	do	do	G-2	1892	Hydraulic, 3-inch	55	55		45		do			Stock		
827	Mrs. E. M. Harvey	do	G-2	1880	Bored, 4-inch	57	57	?55	41	66	do			Domestic; stock		5
828	Mrs. Raibel	do	G-2		Hydraulic, 3-inch	64	64		48		do			Irrigation; stock		2
829	John Turner	do	G-3		Bored, 7-inch	55	55	133	43	67	do			do		
830	L. J. Carter	do	G-3	1886	Bored, 4-inch	53	53	49	40	66	do	45.00		Domestic; irrigation.		8
831	L. S. Carter	do	G-3	1890	do	55	55	65	41		do	45.00		Irrigation		14
832	John Turner	do	G-3		Bored, 7-inch	51	51	42	41	66	do			Domestic; stock		
833	do	do	G-3		Hydraulic, 3-inch	52	52		43	67	do			Domestic; irrigation.		
834	do	do	G-3		do	51	51		41	67	do			Stock		Small.
835	do	do	G-3		do	52	52		40	67	do			Irrigation; stock		
836	J. L. Benight	do	G-3	1903	Hydraulic, 2-inch	45	45	?66	42		do			Domestic; stock		4
837	do	do	G-3		Bored, 4-inch	50	50	62	43	66	do			Irrigation; stock		2
838	John Turner	do	G-3		Hydraulic, 3-inch	50	50		43	66	do			do		
839	do	do	G-3		Bored, 4-inch	48	48		42		do			do		
840	B. F. Townsend	do	G-3		do	44	44		34	67	do			Stock		
841	F. J. Graser	do	G-3		Hydraulic, 3-inch	44	44	?60	43	67	do			Irrigation		2
842	do	do	G-3		Bored, 4-inch	45	45	58	42		do			Irrigation; stock		25
843	do	do	G-3		Hydraulic, 2-inch	44	44	?60	45	65	do			Domestic; stock		
844	A. H. Williams	do	G-3	1903	do	43	43	66	41	66	do	27.00		do		
845	do	do	G-3	?1875	do	43	43	?60	42	66	do			Stock		
846	Mrs. E. A. Raibel	do	G-3	?1870	Bored, 4-inch	43	43	?300	34	68	do			Irrigation; stock		8
847	E. Mitchell	do	F-3	?1876	do	43	43	70	39	65	do			do		
848	do	do	G-3	?1876	Bored, 7-inch	45	45	74	39	65	do			do		
849	do	do	G-3	1900	Hydraulic, 2-inch	48	48	58	32	68	do	20.00		Stock		
850	Mr. Greenleaf	do	F-3		Bored, 6-inch	43	43	?70	43		do			do		Small.
851	A. H. Williams	do	F-3	1899	Hydraulic, 2-inch	44	44	?72	43	66	do	25.00		Irrigation		
852	Mrs. E. A. Raibel	do	F-3	?1870	Hydraulic, 3-inch	42	42	52	40	66	do			Stock		2
853	T. C. Williams	do	F-3		Bored, 3-inch	42	42		38	66	do			Domestic		
857	J. L. Pinney	do	F-4		Bored, 4-inch	38	38	64	34	68	do			Domestic; irrigation; stock.		

Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°F.					*Miner's inches.*
858	J. L. Pinney	Santa Ana	F-3	1904	Bored, 10-inch	37	37	106	34	65	Artesian			Irrigation	
860	J. H. Sanders	do	E-4		Bored, 2-inch, inside of 7-inch.	35	35	?300	37	67	do			Domestic; stock	1
861	J. L. Pinney	do	E-3	?1884	Bored, 4-inch, inside of 7-inch.	36	36	64	34	67	do			Stock	
862	do	do	E-3		Bored, 4-inch	34	34	102	35	66	do			Irrigation	
863	do	do	E-3	1903	do	34	34	187			do			Stock	
864	Mr. Selvidge	do	E-3		do	37	37	96	38	65	do			do	Small.
866	E. C. Martin	do	I-1			125			49		Wind			Domestic; stock	
867	A. O. Birch	do	I-1	1899	Bored, 7-inch	132	112	?45	91		do	$45.00	$50.00	do	
868	P. Allen	do	I-1		Bored, 6-inch	121	91		52		do			Domestic	
869	J. P. Pope	do	I-1		Bored, 7-inch	117	97		151		do			do	
870	Winslow & Decker	do	I-2		do	114	96	52	62		do			do	
871	C. B. Bridgeford	do	I-2	1884	do	100		297	38		do			Domestic; stock	
872	John Cubber	do	I-2		do	107	88	50	68		do			do	
873	A. Fuller	do	I-2	1899	Bored, 10-inch, reduced to 6-inch.	107		360+	71		Gas			Irrigation	†50
874	do	do	I-2	1899	Bored, 6-inch	107		180			Wind			Domestic	
875	W. G. Smith	do	I-2	1878	Bored, 4-inch	110	84	?56	37	66	Hand			Domestic; stock	
876	W. Williams	do	I-2	1876	Bored, 5-inch	113	93	?220	46	67	Wind			do	
877	A. C. Williams	do	I, J-2		Bored, 7-inch	113	90	76	52		Hand			Stock	
878	O. H. Burke	do	I-1		do	118	98	?40	74	66	Wind		270.00	Domestic; stock	
879	C. P. Rice	do	I-1	?1875	do	121		90	52		do			Domestic	

880	B. Fread	do	I-1	?1895	do	128		?140	57	67	do					
881	T. F. Lee	do	I-1	1898	do	128	94	51	86	66	do		65.00	do		
882	Mrs. A. A. Twombly	do	I-1	?1883		128		?50	85	67	Hand			Domestic; stock		
883	J. S. House	do	I-1		Bored, 7-inch	128	103	?55	70		Wind			do		
885	W. H. Clary	do	I-1	?1897	do	132	95	?65	73		do			Domestic		
886	M. A. Menges	do	I-1	?1880	do	132	94	49	98		do			Domestic; stock		
887	Mrs. H. J. Winslow	do	I-1	?1884	Bored, 6-inch	127	103	52	70		do		138.00	do		
888	J. C. Metzgar	do	I-1		Bored, 6-inch, inside of 7-inch.	125	97	56	68		do			do		
889	F. P. Fraser	do	I-1	1902	Bored, 7-inch	125	95	?42	74		Hand		45.00	Domestic		
890	J. F. Schlange	do	I-1		Bored, 6-inch	126	102	28	201		Wind			do		
891	A. McFadden	do	I-1	?1885	Bored, 7-inch	121		60+	59		do			do		
892	W. P. Brown	do	I-1	1901	do	120	100	42	60		do			do		
895	J. S. Leck	do	J-2		do	113	83	?90	37		Hand			Domestic; stock		
896	Mrs. M. Richey	do	J-2	1882	do	110	98	90	68	65	Wind			Domestic		
897	do	do	J-2	?1889	do	110	93	183			Not raised			Not used		
898	Santa Fe R. R. Co	do	J-2		Bored, 8-inch	90	83		55		Hand			Domestic		
899	E. L. Bouman	do	J-2	1901	Bored, 7-inch	104	91	67	140		do			Domestic; stock		
900	F. W. Harding	do	J-2			102			190		Wind			do		
902	T. J. Crawford	do	J-2	1889	Bored, 4-inch	100		?66	82		Hand			Domestic		
903	L. A. Cock	do	J-2	1884	Bored, 7-inch	75	64	?96	52		do			Domestic; stock		
904	P. Ramon	do	J-3	1880	Bored, 4-inch	66	66	120+	52		do			do		
905	E. M. Wheeler	do	K-2	1889		70		45	63							
906	do	do	K-2	1904	Bored, 7-inch	70	64	80	33		Gas		76.80	Stock		†20
907	Irvine Rancho Co	San Joaquin	K-2		Hydraulic, 2-inch	65	65	200	53	68	Artesian			do		
908	S. P. Bowland	Santa Ana	K-2		Bored, 7-inch	85			73	65	Wind			Domestic; stock		
909	W. G. Mitchell	do	K-2	1902		103		96	63		do			do		
911	E. M. Neally	do	J-2		Bored, 7-inch	114			48	66	do			Domestic		
912	S. Stevens	do	J-2		do	115			65		Hand			do		
913	J. B. Bowman	do	J-2		do	113		30+	124		do			do		
914	E. H. Stanley	do	J-2	1897	Hydraulic, 2-inch	113	106	280+			Wind			Domestic; stock		
915	C. C. Cozzad	do	J-2	?1884		112		?100	107		Wind, hand			do		
916	Louis Ebel	do	J-2			112		?140			Hand			Domestic; irrigation.		
917	G. G. Godfrey	do	J-2	1879	Bored, 7-inch	112	100	?250	86		do			Domestic		
918	E. M. Crellin	do	J-2	?1895	do	115	88	166	42		Wind			Domestic; stock		

Wells in the Santa Ana quadrangle—Continued.

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						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
919	W. C. Crawford	Santa Ana	J-2	1898	Bored, 7-inch	116		?69	78		Wind			Domestic	
921	P. T. Adams	do	J-1		do	120			56		do			Domestic; stock	
922	I. L. Marchant	do	J-1	?1889	do	125		?130	57		do			Domestic	
923	H. A. Allen	do	J-1			128	95	86			do			Domestic; stock	
924	F. E. Monahan	do	I-1	1884	do	133	97	52			do			do	
925	Mrs. M. L. Adams	do	I-1	?1888	do	133			70		do			do	
926	J. M. Raugh	do	I-1	?1889	do	133		?90	81		do		$140.00	do	
928	Mrs. A. C. Gulick	do	J-1	?1880	do	133	93	47	72		do			do	
929	L. F. Sheets	do	J-1	1879	Bored, 4-inch	133	90	300±	56		do			do	
930	Geo. Liggett	do	J-1		Bored, 7-inch	130		?80	75		Hand			do	
931	L. Hillyard	do	J-1	?1892	do	130	100	?60	77		Wind			do	
932	Mrs. S. E. Wilcox	do	J-1	1880	do	130		?80			do			do	
933	V. V. Tubbs	do	J-1	?1873	do	140		75	54		Wind, gas			do	
934	do	do	J-1	1902	do	140	87	202			Not raised			Not used	
935	H. Diers	do	J-1		do	133	81	56	115		Wind			Domestic; stock	
936	Henry Leek	do	J-1	?1880	do	132	112	?100	62		do			Domestic	
937	J. T. Morehead	do	J-1	1894	do	132	92	103	59		do	$68.00	170.00	Domestic; stock	
938	M. E. Phillips	do	J-1	1890	do	134	94	70	87		Hand			Not used	
939	C. B. Leddick	do	J-1		do	137			59		Wind			Domestic; stock	
940	C. W. Bowers	do	K-1	1886	do	132	79	?67	60		do			do	
941	J. S. Rice	do	K-1		Hydraulic, 8-inch	135			61	66	do			do	
942	James Smith	do	K-1		Bored, 7-inch	128			48		Hand			do	
943	E. Chast	do	K-1	1894	Hydraulic, 8-inch	131	91	50	48		Wind			do	

944	*Mr. Thorpe*	*do*	*K-1*	*1888*	Bored, 7-inch	135			44		Hand			Not used	
945	*A. L. Paul*	*do*	*K-1*	*1902*	*Dug, 3 by 3 foot*	135	85	100+	50		do			Domestic; stock	
947	*Mrs. M. J. Clifford*	do	K-1	*1886*	*Bored, 7-inch*	127		61	57		do				
948	E. L. Bouman	do	K-1		Dug, 3 by 3 foot; bored, 7-inch.	128		?120	45		do			Domestic; stock	
949	Mr. Ross	do	K-1		Bored, 7-inch	128	78	?120	58		Wind			do	
950	John Taylor	do	K-1	1884	Dug, 4 by 4 foot	125	78	50	53		Hand			do	
951	C. M. Halderman	do	K-1		Bored, 6-inch	33	87	77			Not raised			Not used	
952	do	do	K-1		Bored, 7-inch	32			46		Wind			Domestic; stock	
953	G. W. Diffenderfer	do	J-1	1895		130		80	60		do			do	
954	David Hewes	do	J-1		Bored, 7-inch	128	89	115	57		do			Domestic	
956	C. E. Utt	do	J-1	1897	Bored, 10½-inch	127	102	450	52		Gas			do	10
958	J. O. Pebele	do	J, K-1	1885	Dug, bored, 7-inch	127	97	57	57		Wind	97.00		do	
959	Irvine Rancho Co	Lomas De Santiago.	M-3	?1876	Bored, 7-inch	135	96	300+	131		do			Stock	
960	do	do	M-2	?1877	do	135	127	?400	59	68	do			Domestic	
961	do	San Joaquin	L-2	1897	do	74	72	?350			Not raised			Not used	
962	do	Santa Ana	I-4	1878	do	47	47	?200	41	70	Artesian			Irrigation; stock	
963	do	do	K-1	1890	do	117	105	?80	53	70	Wind			Domestic; stock	
964	do	San Joaquin	M-7	1891	Bored, 6-inch	168	156	200	60		Wind, horsepower.			do	
965	do	Santa Ana	F-7	1891	do	63	63	200			Artesian			Irrigation	3
966	do	do	F-7	1891	do	63		200	25		Hand				
967	do	Lomas De Santiago.	L-4	1891	Bored, 7-inch	100	100	300+	69	73	Artesian			Not used	Small.
968	do	do	M-2	1894	Bored, 8-inch	138	117	719	43		Steam			Irrigation	†15
970	do	San Joaquin	H-6	1897	Hydraulic, 2-inch	55	55	125	22		Artesian			Domestic	4
971	J. Morris	Lomas De Santiago.	M-2	1897	Bored, 6-inch	150	120	?100	115		Wind			Domestic; stock	
972	Irvine Rancho Co	do	M-6	1897	Bored, 7-inch	160	107	163	69		do			do	
974	do	San Joaquin	K-6	1897	Dug, 4 by 4 foot	80	68	14	79		do			do	
975	S. T. Rutherford	do	K-5	1897	Dug, 3½ by 3½ foot	80	76	16			do			do	
976	Mr. Warne	Santa Ana	G-5	1897	Hydraulic, 2-inch	48	48	158	35	71	Artesian			Not used	Small.
977	Irvine Rancho Co	San Joaquin	L-3	1898	do	75	75	400	53	71	do	240.00		Stock	5
978	do	do	K-4	1898	do	65	65	362	72		do	240.00		do	Small.
979	do	do	J-5	1898	do	55	55	288							4
981	do	do	I-7	1898	do	50	50	165	80	81	Artesian			Stock	9

Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
982	Irvine Rancho Co	San Joaquin	I–4	1898	Hydraulic, 2-inch	43	43	204	46	71	Artesian			Stock	7
983	do	do	J–4	1898	do	45	45	138	46	71	do			do	6
984	do	do	J–3	1899	do	48	48	160	49	72	do			do	5
988	do	do	H–6	1899	Hydraulic, 3-inch	60	60	210	37	71	do			do	3
989	do	do	H–6	1899	Hydraulic, 2-inch	55	55	140	25	75	do			Domestic; stock	6
990	do	Santa Ana	I–3	1899	Hydraulic, 4-inch	72	72	351	43		do			Irrigation	†25
991	do	do	J–3	1899	do	65	65	183			do			do	
993	do	San Joaquin	N–6	1899	Hydraulic, 4-inch, 155 feet; hydraulic, 2-inch, 141 feet.	200		296	69		Wind			Domestic	
1002	do	do	H–7	1899	Hydraulic, 3-inch	60		397	34	79	Flows into reservoir.			Stock	Small.
1003	do	Santa Ana	K–1	1900	Hydraulic, 2-inch	108		208	42		Not raised			Not used	
1006	do	San Joaquin	L–2	1900	do	75	75	189	42		Artesian			Stock	
1011	do	do	J–6	1900	do	25	25	163	52	72	do			do	
1012	do	do	I–6	1900	Hydraulic, 3-inch	35	35	70			do			Irrigation	19
1015	do	do	I–6		do	28	28	88	28	77	do			do	2
1016	do	do	H–7		Hydraulic, 2-inch	40	40	226	31	70	do			Artificial pond	
1020	do	do	H–7		do	40	40	112	32	77	do			Domestic	2
1024	do	do	J–6	1900	Hydraulic, 3-inch	25	25	122	66	72	do				10
1027	do	do	J–6	1900	Hydraulic, 2-inch	25	25	51	57	72	do			Stock	4
1028	do	do	I–6	1900	Hydraulic, 3-inch	55	55	80			do				

1085	....do	Lomas De Santiago.	M-2	1900	Bored, 10-inch	150	130	317								
1039	....do	San Joaquin	I-6	1900	Bored, 7-inch	35	35	298	31	70	Artesian			Irrigation		
1040	....do	....do	I-6	1900	....do	35	35	91	26	77	....do			....do		
1046	....do	Santa Ana	J-3	1901	Bored, 10-inch	65	65	193	40	69	....do			....do		†18
1047	....do	Lomas De Santiago.	L-1	1901	Bored, 12-inch	145		164	49	75	Gas			....do		32
1040	....do	San Joaquin	L-2	1901	Bored, 10-inch	75	73	252	45		Wind			Domestic; stock		
1051	....do	Lomas De Santiago.	N-4, 5	1903	Hydraulic, 4-inch	220	100	246	141		....do	$117.50	$60.00	....do		
1054	....do	....do	N-4	1903	....do	115		200				30.00				
1056	....do	....do	N-4	1903	....do	215	135	271	90		Wind	96.25	60.00	Domestic		
1058	....do	....do	N-3	1903	....do	120		321			....do	49.50		....do		
1062	....do	....do	L-2	1903	Bored, 15-inch	130	102	400				925.33				
1064	....do	San Joaquin	N-6	1903	Hydraulic, 8-inch, inside of 4-inch.	200	126	368				85.00				
1066	....do	....do	M-6	1903	Hydraulic, 4-inch	140		75				22.00				
1069	....do	....do	L-6		....do	135	70	114				45.00				
1071	....do	Santa Ana	F-7	1904	....do	65		210				33.00				
1073	....do	....do	G-6	1904	Hydraulic, 3-inch	50	50	152	22	75	Artesian	44.00		Stock		9
1075	....do	....do	?-4	1904	Hydraulic, 4-inch	52	52	394	44	68	....do			Irrigation		
1077	....do	....do	I-3	1904	....do	55	55	415	42	72	....do			Not used		
1084	W. H. Best	....do	K-1	1900	Bored, 10-inch	110	100	?375	44		Hand					
1085	W. L. G. Haskins	....do	K-1	1893	Bored, 7-inch	110	98	51	56		....do	51.00		Domestic; stock		
1086	Hayrod Bros.	Lomas De Santiago.	M-1	1902	Dug, 4 by 4 foot	275	252	30			....do			Stock		
1087	Wm. Jeffrey	San Joaquin	L-5	?1894	Dug, 3½ by 3½ foot	90	75	16	83	68	Wind			Domestic; stock		
1088	W. D. Bowman	Santa Ana	L-1	1904	Bored, 7-inch	95		58	49		Hand	60.00	16.00	....do		
1089	Cubben & McFadden.	Lomas De Santiago.	M-5	1908	....do	140	100	100+	78	73	Gas			Domestic; irrigation; stock.		†27
1090	Fred Page	San Joaquin	L-6	1901	Dug, 2 by 4 foot	98	71	28	91	65	Wind			Domestic		
1092	C. S. Hubbard	Santa Ana	K-2	1892	Bored, 6-inch	75	65	?26	57		Hand			Domestic; stock		
1093	....do	....do	K-2	1890	....do	80	68	?50	61	68	Hand; wind			....do		
1095	B. E. Buck	....do	K-1	?1893		115			54	65	Hand			Domestic		
1096	C. C. Lambert	....do	K-1	1892	Bored, 8-inch	115	80	?70	53		Wind			....do		
1097	Mr. Cullom	....do	K-1		Bored, 7-inch	115	89	34	55		Hand			Domestic; stock		

Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
1098	E. E. Cook	Santa Ana	K-1		Bored, 7-inch	115	93	25	56		Wind			Domestic; stock	
1099	M. W. Johnson	do	K-2	1894	do	100		118	56		do			Domestic	
1101	Mr. Higgins	do	K-2		Bored, 6-inch	95			57	68	do			Domestic; stock	
1102	Thos. Rawling	do	K-1		Bored, 7-inch	100			183		Hand			Domestic	
1103	Wm. McGreevy	do	I-1		Bored, 6-inch	103	66	42	62		Wind			do	
1104	Wm. Halesworth	do	I-1		do	103		?55	65		do			do	
1106	G. R. Smith	do	I-1		Bored, 7-inch	135	97	46	73	67	do			do	
1107	M. P. Mathews	do	I-1		do	140		52	55		do			do	
1108	H. C. Babcock	do	I-1	1901	Dug, 4-foot diameter.	148	95	54	95		Hand			do	
1109	Mrs. S. W. Baker	do	I-1	1899	Bored, 7-inch	133		49	66						
1110	J. E. Taylor	do	I-1	1900	do	133	96	48	73	65	Wind, electric motor.			Domestic	
1111	J. B. Joplin	do	I-1	1888	do	133		46	70	67	Wind			do	
1112	H. W. Lewis	do	J-1	1901	do	135			52		do	$100.00		do	
1114	H. A. Allen	do	J-1	?1883	Bored, 6-inch	130		?160	65		do			do	
1115	Mrs. Hilton	do	J-1		Bored, 7-inch	130			71		do			do	
1116	L. Carrier	do	J-1	?1888	do	130	97	76	61		do			do	
1117	W. H. Comstock	do	J-1	?1894	do	125	94	62	68		do			do	
1118	J. Griset	do	J-1	1902	do	130		100+	63		Hand			do	
1120	A. G. Campbell estate	do	J-2	?1897	do	115		56	63		Wind			Domestic; stock	
1121	Mrs. S. P. Turner	do	J-1	1899	do	115	98	?110	59		do	111.00		Domestic	
1122	Mr. Wullingberger	do	J-2	1878	do	115	85	80	64		do			do	

1123	E. L. Higgins	do	J-1	1884	do	118		?65	60		do				do		
1124	John Awe	do	J-1	1892	do	120		?80	52		do				do		
1125	J. W. Ballard	do	J-1		do	120			48		do				do		
1126	Geo. Preble	do	J-1			125		90			do				do		
1127	W. L. Adams	do	J-1	?1879	Bored, 6-inch	125	112	450			Not raised				Not used		
1128	Thompson Bros	do	J-3	1900	Bored, 7-inch	55	55	284	48	73	Artesian				Domestic; irrigation; stock.		
1129	do	do	J-3	1900	do	53	53	282	50	68	do				do		1
1131	Robert Boyd	do	I-4	1902	Hydraulic, 2½-inch.	45	45	108	40	68	do				do		5
1132	Irvine Rancho Co	San Joaquin	G-8	?1895	Bored, 7-inch	100	25	?150	161		Wind				Stock		
1133	W. W. McCarrell	Santa Ana	F-4	1903	Dug, 3½ by 3½ foot.	40	32	13	151	62	Hand				do		
1134	B. W. Ellis	do	F-4	1903	Hydraulic, 2-inch	40	40	?230	35	63	Artesian				Domestic; stock		3
1135	do	do	F-4	?1881	Bored, 4-inch	40	40	?190	39		do				Stock		
1136	do	do	F-4	?1884	do	38	38	?190	25	62	do				Irrigation		
1137	Fred Raibel	do	E-4		Hydraulic, 2-inch	35	35		30	63	do				Domestic		
1138	I. M. Von Schriltz	do	E-4	1902	Bored, 4-inch	35	35	200+	29	66	do				Stock		
1139	do	do	E-4	1903	Bored, 10-inch	35	35	?400	32	68	do				Irrigation		1
1140	do	do	E-4		Bored, 4-inch	35	35	141	30	65	do				do		1
1141	do	do	E-4		do	35	35	152	29	66	do				do		1
1142	Mrs. Mary Smith	do	E-4	?1874	Hydraulic, 3½-inch.	35	35	?312	38	65	do				Domestic; stock		Small.
1143	P. J. Matthews	do	E-4		Bored, 4-inch	35	35		30	65	Artesian, hand.				do		
1144	Mr. Davis	do	E-4		Bored, 6-inch	35	35		34	67	Artesian				Domestic; irrigation; stock.		
1145	J. W. De Witt	do	F-4		Bored, 3½-inch	42	42	185	32	66	do				do		
1146	do	do	F-4	1889	Bored, 4-inch	40	40	?225	36	65	do				Irrigation; stock.		
1148	R. W. McClain	do	F-4			42			34		do						
1149	do	do	F-4		Bored, 4-inch	42	42	375	32		Not raised				Not used		
1150	W. H. Kedford	do	F-4	?1874	Bored, 3½-inch	45	45		37		Artesian				Domestic; stock		
1151	Newport school district.	do	F-4		Hydraulic, 2-inch	43	43		37		do				Domestic		
1152	W. F. Cullen	do	F-4	1874	Bored 4-inch	43	43	160	37		do				Domestic; irrigation; stock.		
1153	E. S. Wakeham	do	F-4	?1884	Hydraulic, 2-inch	43	43	310	30	71	do				do		
1154	do	do	F-4	?1874	Bored, 7-inch	43	43	?160	68	69	do				Stock		

Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
1155	M. H. Bear	Santa Ana	G-4	1894	Hydraulic, 2-inch	40	40	125	39	....	Artesian			Domestic; irrigation; stock.	.....
1156	Thos. Armstrong	do	G-4	?1880	Bored, 4-inch	40	40	?180	38	....	do			do	.....
1157	do	do	F-4	.....	do	45	45	?90	30	67	do			Stock	.....
1158	J. G. Lynch	do	G-4	1884	.....	40	40	195	37	69	do			Irrigation	.....
1159	G. W. Ford	do	G-4	1884	Bored, 4-inch	40	40	210	39	....	do			do	11
1160	L. Wakeham	do	G-5	.....	Hydraulic, 4-inch	40	40	320	32	72	do			Domestic; irrigation.	11
1161	T. J. Mitchell	do	G-5	?1885	Dug, 3½ by 3½ foot.	40	36	8	32	62	Hand			Stock	.....
1163	J. E. Garner	do	G-4	.....	Bored, 4-inch	40	.....	30	40	....	do			Domestic	.....
1164	do	do	G-4	.....	do	40	.....	60	39	....	do			Stock	.....
1165	F. D. Leonard	do	G-4	.....	do	40	.....	.....	43	....	do			Domestic; stock	.....
1166	Wm. Gracer	do	F-4	1901	Hydraulic, 2-inch	42	42	325	29	....	Artesian	$225.00	.....	do	Small.
1167	do	do	F-4	?1884	Bored, 7-inch	40	40	.....	35	....	do			Irrigation	9
1168	Mr. Stanley	do	E-4	.....	.....	40	40	.....	37	....	do			.....	.....
1169	L. A. Mann	do	E-4	1902	Bored, 3-inch	35	35	326	33	69	do	.....	.....	Domestic; irrigation; stock.	†11
1170	Sherman Babb	do	E-4	1900	Bored, 4-inch	35	35	326	29	....	do	300.00	.....	Irrigation; stock	.....
1171	Wm. Gracer	do	E-4	1884	do	32		?100	32	68	Hand			Domestic; stock	.....
1172	Edwin Snow	do	E-4	1886	Bored, 6-inch	30	30	300+	28	71	Artesian			Domestic; irrigation.	†60
1173	G. B. Streeter	do	F-4	.....	Bored, 4-inch	45	45	.....	40	....	do			Domestic; stock	.....
1174	A. T. Cole	do	F-4	1894	Hydraulic, 2-inch	40	40	?108	35	67	do			do	.....
1175	do	do	F-4	?1880	Bored, 4-inch	40	40	[illegible]	[illegible]	[illegible]	do			Irrigation	.....

1176	J. S. Brooks	do	F-5		do	40	40		39	68	do			Domestic; stock	
1177	Ben Forward	do	F-5		Bored, 7-inch	40	40		37	67	do			Domestic; irrigation; stock.	Small.
1178	J. T. Harris	do	F-5		Bored, 4-inch	47	47	108	30		do			Domestic; irrigation.	
1179	H. A. Bingham	do	F-5		Bored, 3-inch	50	50	200+	33		do			Domestic; irrigation; stock.	Small.
1180	do	do	F-5		Hydraulic, 2-inch	55	55		36	68	do			Domestic	
1181	J. C. Hopkins	do	F-5	?1886	Bored, 4-inch	50	50	?180	29	72	do			Domestic; irrigation; stock.	17
1182	F. D. Leonard	do	F-6	?1875	Bored, 7-inch	72	72	316	25	78	do			Irrigation	11
1183	do	do	F-5	1902	do	45	45	170	32	67	do			Domestic; stock	
1184	Fairview Colony	do	F-5	?1886	Bored, 4-inch	50	50	154	26	73	do			Domestic; irrigation.	5
1185	do	do	G-5	?1875	Bored, 3-inch	45		70			Not raised			Not used	
1186	J. Speed	do	G-5	1898	Hydraulic, 3-inch	45	45		33	71	Artesian			Domestic; irrigation; stock.	
1187	Fred Chatterton	do	G-5	1898	Bored, 4-inch	45	45	182	31	69	do	100.00		do	
1188	do	do	G-5	1886	do	45	37	200			Not raised			Not used	
1189	Fairview Colony	do	G-5	?1875	do	45	45	105			do			do	
1190	T. J. Mitchell	do	G-5	?1886	do	40	40	180			Artesian			Stock	
1191	do	do	G-5	1886	Bored, 7-inch	40	40	?180			do			do	
1192	M. A. Baker	do	G-5	?1894	Bored, 4-inch	45	43	?180	31	67	Not raised			Not used	
1194	Fairview Colony	do	G-5	?1880	Hydraulic, 3-inch	45	45	?175	33		Artesian			Irrigation; stock	
1195	J. L. Goodwin	do	G-5	1898	Bored, 3-inch	45	45	228	26	72	do			Domestic	
1196	O. B. Hallock	do	F-5	?1899	Hydraulic, 3-inch	45	45	160	33		do	80.00		Domestic; stock	
1197	do	do	G-5	1902	do	45	45	220	26	72	do	110.00		Irrigation	Small.
1198	A. A. Holden	do	F-5		Bored, 4-inch	45	45		31	72	do			Domestic; irrigation; stock.	5
1200	Mr. Lurvey	do	G-5	1901	Hydraulic, 2-inch	45	45	333	21	70	do			Domestic; irrigation.	Small.
1201	Mr. Einhoff	do	D-8	1902	Bored, 7-inch	98	68	675			Not raised			Not used	
1202	C. T. Platt	do	F-5	1904	Bored, 12-inch	48	48	294	36	71	Artesian			Irrigation	
1203	G. Leibermann	do	G-5	1902	Hydraulic, 2-inch	45	45	360	33	69	do	120.00		Domestic; irrigation; stock.	
1204	Mr. Stevens	do	G-5		Bored, 4-inch	45	45	178	27	73	do			do	4
1205	M. A. Baker	do	G-5		do	48	48	120	32	73	do			do	1
1206	Irvine Rancho Co	do	G-6		Dug, 3 by 3 feet	48			81		Hand			Domestic; stock	

Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
1207	G. Leibermann	Santa Ana	G-5	1886	Bored, 3-inch	45	45	?180	33		Artesian			Irrigation; stock.	
1208	C. M. McClintock	do	F-5	?1870	Bored, 7-inch	40	40		38	67	do			Domestic; irrigation; stock.	
1209	do	do	F-5	?1880	Bored, 4-inch	40	40	125			do			Stock	
1210	J. H. Meyer	do	E-6	?1886	Bored, 7-inch	72	72	360	33		do			Domestic; stock	
1211	H. D. Meyer	do	D-6	1897	Dug, 4 by 4 foot	25	20	14	96		Wind			Domestic; irrigation; stock.	
1212	W. L. Adams	do	D-6	1904	Bored, 7-inch	25	19	528	96	72	Not raised			Not used	
1213	do	do	D-6	1879		25	19	400	98		Wind				
1214	Mr. Powell	Las Bolsas	D-5		Hydraulic, 2-inch	25	25	?100	31	66	Artesian			Stock	
1215	W. S. Brunton	do	C-5	?1899	Hydraulic, 1½-inch.	25	25	90	31	66	do			Domestic; stock	Small.
1218	Wm. Lamb	do	C-5	1895	Hydraulic, 2-inch	33	33	118	29	65	do			Irrigation; stock.	
1219	do	do	C-5		do	33	33	98	31	66	do			Stock	
1220	do	do	C-5		do	32	32	108	28	66	do			do	
1221	do	do	C-5		do	33	33	108	30	64	do			do	
1222	A. T. Swift	do	B-5	1904	Bored, 7-inch	35	35	130	27	65	do	$160.00		Domestic; irrigation; stock.	19
1223	do	do	B-5	1904	do	36	36	134	29	65	do	160.00		Irrigation	19
1224	do	do	B-5	?1897	Hydraulic, 2-inch	35	35	760	27	66	do			Stock	
1225	I. M. Von Schriltz	do	E-4		Bored, 4-inch	32	32	65	36	66	do			do	
1226	do	do	D-4	1904	Bored, 6-inch	32	32	112	33	64	do			Irrigation; stock.	6
1227	Wm. Lamb	do	B-5	1890	Bored, 4-inch	34	34	108	29	66	do			Stock	
1228	do	do	B-5		Bored, 3-inch	34	34		30		do			Domestic	

1229	.....do	.....do	B–5	.....	Bored, 4-inch	34	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Irrigation	21
1231	.....do	.....do	B–5	1904	Bored, 3-inch	33	33	88	30	.....	.....do	.....	.....	.....	.....do		19
1232	.....do	.....do	B–5	?1900	Bored, 2-inch	32	32	89	27	65	.....do	.....	.....	.....	Domestic; stock		.....
1233	.....do	.....do	B–6	?1899	.....do	30	30	108	.....	.....	.....do	.....	.....	.....	Not used		.....
1234	.....do	.....do	B–6	.....	Bored, 3-inch	27	27	128	.....	.....	.....do	.....	.....	.....	Stock		.....
1235	.....do	.....do	C–6	.....	Hydraulic, 2-inch	27	27	87	27	.....	.....do	.....	.....	.....	.....do		.....
1236	.....do	.....do	C–5	1899	.....do	32	32	80	.....	.....	.....do	.....	.....	.....	Not used		.....
1237	.....do	.....do	C–5	.....	.....do	31	31	80	26	67	.....do	.....	.....	.....	Irrigation		.....
1238	.....do	.....do	C–6	.....	.....do	34	34	?80	27	65	.....do	.....	.....	.....	.....do		6
1239	.....do	.....do	C–6	.....	.....do	34	34	80	.....	.....	.....do	.....	.....	.....	.....do		.....
1240	.....do	.....do	C–5	1885	.....do	28	28	114	30	65	.....do	.....	.....	.....	Stock		.....
1241	.....do	.....do	C–5	1885	Bored, 2-inch	27	27	.....	27	.....	.....do	.....	.....	.....	Irrigation; stock		8
1242	H. S. Worthy	.....do	B–5	1893	Bored, 4-inch, inside of 7 inch.	36	36	.....	29	64	.....do	.....	.....	.....	Domestic; irrigation.		.....
1243	A. L. Whitesides	.....do	B–5	1904	Bored, 7-inch	40	40	123	28	63	.....do	127.00	.....	.....	.....do		12
1244	C. E. and E. Griset	.....do	A–5	1903	Bored, 6-inch	60	60	104	29	66	Gas	75.00	$1,000.00	.....	Irrigation		†20
1245	Mrs. Belle Martin	.....do	A–4	.....	.....	60	.....	.....	29	.....	Wind	.....	.....	.....	Domestic		.....
1246	T. A. Wells	.....do	B–4	1904	Bored, 7-inch	60	60	174	31	65	Gas, artesian	.....	375.00	.....	Domestic; irrigation; stock.		†23
1247	W. E. Wells	.....do	B–4	1901	Hydraulic, 2-inch	60	60	.....	27	65	Artesian	.....	.....	.....	.....do		.....
1248	J. B. Raine & Son	.....do	A–4	1901	Bored, 7-inch	75	42	83	30	.....	Gas	.....	.....	.....	Manufacturing		†40
1249	La Bolsa Tile Co.	.....do	A–4	1903	Bored, 6-inch	75	42	86	29	.....	Steam	86.00	.....	.....	.....do		.....
1250	Huntington Beach Co.	.....do	A–5	1900	Bored, 10-inch	70	66	400	.....	.....	Gas	500.00	100.00	.....	Irrigation		†35
1251	.....do	.....do	A–5	1897	Bored, 8-inch	70	.....	870	43	74	.....do	.....	.....	.....	.....do		†15
1252	.....do	.....do	A–6	1900	Bored, 10-inch	70	68	400	.....	.....	.....do	500.00	.....	.....	.....do		†35
1253	.....do	.....do	A–6	1898	Bored, 8-inch	70	.....	135	.....	.....	.....do	.....	.....	.....	.....do		†30
1254	.....do	.....do	A–5, 6	1898	Bored, 6-inch	70	.....	75	.....	.....	Compressed air	.....	.....	.....	.....do		†40
1255	.....do	.....do	A–6	1897	.....do	70	.....	?250	24	68	Wind	250.00	150.00	.....	Domestic		.....
1256	A. W. Brown	.....do	B–6	1898	Bored, 2-inch	24	24	95	25	67	Artesian	.....	.....	.....	Stock		.....
1257	.....do	.....do	B–6	1901	Bored, 7-inch	25	25	?130	29	.....	.....do	.....	.....	.....	Irrigation		.....
1258	L. T. Wells	.....do	B–5	1903	Bored, 4-inch	32	32	?80	29	66	.....do	.....	.....	.....	Domestic; stock		4
1259	.....do	.....do	B–5	1901	Hydraulic, 2-inch	32	32	....	29	64	.....do	.....	.....	.....	Irrigation		.....
1260	.....do	.....do	B–6	1901	Bored, 3-inch	30	30	102	29	64	.....do	.....	.....	.....	.....do		5
1262	A. L. Whitesides	.....do	B–5	1904	Hydraulic, 2-inch	35	35	?114	.....	.....	Artesian	65.00	.....	.....	.....do		†4
1264	.....do	.....do	B–5	.....	Bored, 3-inch	35	35	101	28	.....	.....do	.....	.....	.....	.....do		11
1265	J. L. Worthy	.....do	B–5	.....	Bored, 4-inch	32	32	100+	28	65	.....do	.....	.....	.....	.....do		.....

Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
1268	J. B. Bushard	Las Bolsas	B-6	1901	Bored, 3-inch	24	24	80	27	66	Artesian			Domestic; irrigation.	† 16
1269	do	do	B-6	1899	Hydraulic, 2-inch	25	25	80	27	66	do			Irrigation	4
1270	do	do	B-6	1899	do	21	21	87	28	64	do			do	† 9
1272	do	do	B-6	1900	Bored, 3-inch	24	24	80	27	64	do			Stock	
1273	do	do	B-6	1898	Bored, 7-inch	22	22	90	27	65	do			Irrigation	2
1274	J. C. Farnsworth	do	B-6	1898	do	20	20	100	27	65	do			Not used	
1276	Caspar Borchard	do	C-6	1898	Hydraulic, 2-inch	23	23	85	28		do			Irrigation	3
1277	do	do	C-6	1901	Bored, 3-inch	20	20	85	27	67	do			do	9
1278	do	do	C-6	1901	do	20	20	85	26	67	do	$65.00		do	9
1279	do	do	C-6	1900	Hydraulic, 2-inch	19	19		29	68	do			do	4
1280	do	do	C-6	1901	Bored, 3-inch	23	23	85	27	66	do			Domestic; irrigation; stock.	† 12
1281	John Borchard	do	A-7		Bored, 4-inch	35	1	?34	25		Wind			Domestic; stock	
1282	Lydia A. Timmons	do	A-7		Bored, 7-inch	50	7	81	25		do	35.00		do	
1283	J. M. Hearn	do	A-7	1902	do	50		117	26		do	50.00		do	
1284	David Brush	do	A-6	1901	do	35	7	520	28		do	1,000.00	$200.00	do	
1285	N. Cary	do	A-6	1902	Hydraulic, 2-inch	35		?70	25		do	30.00		do	
1286	O. Utterssport	do	A-6		Bored, 7-inch	38	15	133	25		do			do	
1287	A. W. Brown	do	A-6	1903	do	50		84	66		do			do	
1288	W. T. Newland	do	A-6	1902	Bored, 4-inch	50	27	79	26		do	50.00	65.00	do	
1289	O. Utterssport	do	A-6	1901	Hydraulic, 2-inch	25	25	55	30		Artesian	50.00		Stock	
1289a	do	do	A-6	1901	Hydraulic, 3-inch	25	25	55	80		do			do	

1290	James Robinson	do	A-5	1901	Hydraulic, 4-inch	23	23	116	25		do		100.00		Domestic	Small.
1291	O. Uttersport	do	A-6		Bored, 2-inch	23	23	70	27		do		50.00			6
1292	W. T. Newlands	do	B-6	1900	Bored, 4-inch	23	23	108	27		do		27.00		Not used	†33
1293	do	do	B-6	1900	Bored, 3-inch	23	23	106	24		do				Irrigation	18
1294	Caspar Borchard	do	C-5	1898	Hydraulic, 2-inch	26	26	85	25	72	do				Domestic; irrigation; stock.	4
1295	do	do	C-5	1904	Bored, 3-inch	25	25	85		70	do				Irrigation	12
1296	do	do	C-5	1904	do	25	25	85	25	70	do				do	12
1297	do	do	C-5	1904	Hydraulic, 3-inch	25	25		25		do				do	18
1298	do	do	C-5	1904	do	24	24	85	25		do				do	28
1299	do	do	C-5, 6	1900	Hydraulic, 2-inch	24	24				do				do	4
1300	do	do	C-5	1900	do	24	24	85	26		do				do	6
1301	W. T. Newlands	do	B-6	1900	do	24	24	101	25		do				do	10
1302	Caspar Borchard	do	B, C-6	1900	do	20	20	85	25		do				Domestic	
1303	J. C. Farnsworth	do	B-6	1904	Hydraulic, 3-inch	20	20	92	27		do				Domestic; irrigation; stock.	11
1304	J. C. Townsend	do	B-7		Bored, 4-inch	18	18	98	27		do				Irrigation	†28
1305	J. M. Broad	do	B-7		do	18	18	137	27		do				do	1
1306	do	do	B-7			18	18		26		do				do	
1307	Mr. Woods	do	C-7		Hydraulic, 2-inch	14	14	81	25	66	do				Not used	
1308	N. J. Sanders	do	C-7		Bored, 4-inch	13	13		26		do					
1309	J. W. Sowles	do	C-6		Hydraulic, 2-inch	17	17	86	124		do					
1310	do	do	C-6	1899		18	18	?75	25		do				Domestic; stock	
1312	do	do	C-6		Hydraulic, 2-inch	19	19	91	29		do				Irrigation	3
1314	Henry Hockmeyer	do	C-7	1899	Hydraulic, 3-inch	10	10	87	26		do				do	5
1315	Mr. Meyers	do	C-7		Hydraulic, 2-inch	23	23	51	107	63	Siphon				Domestic; stock	
1316	Banning Bros	do	C-8		Dug, 2 by 8 foot	24	22	5	117		Wind				do	
1317	Mr. Snow	Santa Ana	D-5		Bored, 6-inch	55	55		22		Artesian				Domestic; irrigation; stock.	
1318	Henry Hockmeyer	Las Bolsas	B-7	1901	Hydraulic, 2-inch	12	12	111	25		do		42.00		do	†4
1319	do	do	B-7	1899	Bored, 7-inch	13	13	126	26		do		126.00		Stock	19
1320	do	do	B-7		Hydraulic, 2-inch	12	12	98	25		do		47.00		Irrigation	4
1321	do	do	B-7	1901	do	9	9	?106	29		do		38.00		do	
1323	Pacific Gun Club	do	C-8		Hydraulic, 3-inch	8	8	83	93	67	do				Stock	
1324	do	do	C-8		Hydraulic, 2-inch	5	5	98	155		do				do	
1326	do	do	C-8	1902	Bored, 4-inch	2	17—	100	66						Artificial pond	

Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
1327	Mr. Meyers	Las Bolsas	C-7		Hydraulic, 2-inch	9	9	?90	29	....	Artesian	$32.00		Domestic; stock	
1328	John Borchard	do	B-7	?1899	do	15	15	100+	28	64	do			do	
1329	do	do	B-7	?1899	do	13	13	100+	28	63	do			Domestic	
1330	W. T. Newlands	do	B-7		Bored, 4-inch	17	17	?130	30	66	do			Irrigation	
1331	J. S. Rice	Santa Ana	D-5		do	40	40	192	26	71	do			Domestic; irrigation; stock.	
1332	do	do	D-5		Bored, 7-inch	50	50		23	72	do			Irrigation; stock	
1333	R. J. Webster	Las Bolsas	D-5	1904	Bored, 4-inch	27	27	75	35	65	do			do	4
1335	J. E. Snow	Santa Ana	D-5		Hydraulic, 3-inch	50	50	182	23	72	do			do	4
1336	do	do	D-5		Bored, 3-inch, inside of 6-inch.	50	50	218	24	70	do			Stock; irrigation.	3
1337	do	do	D-5	1903	Bored, 4-inch	50	50	?230	22	....	do			Domestic; stock	4
1338	do	do	E-5		Hydraulic, 3-inch	50	50	157	28	....	do			Irrigation; stock.	2
1339	W. S. Brunton	do	E-5	?1899	Bored, 3-inch, inside of 7-inch.	50	50	?200	26	73	do			Domestic	†2
1340	Clark Bros. & Babb	do	E-5	1896	Bored, 4-inch	50	50	?250	30	....	Wind			Domestic; stock	
1341	George H. Clark	do	E-5	?1901	Hydraulic, 3-inch	47	47	180	29	....	Artesian			do	Small.
1342	do	do	E-5	1904	Bored, 12-inch	42	42	375+		....	do			Irrigation.	
1343	do	do	E-5	1896	Bored, 7-inch	51	33	265	30	....	Wind			Stock	
1344	L. Montgomery	do	E-5	1896	Bored, 4-inch	52	52	280	25	....	Artesian			Domestic; irrigation; stock.	†45
1345	Geo. W. Grifiths	do	E-5	1892	Bored, 6-inch	52		320	31	....	Wind			do	
1346	Clark Bros. & Jefferson.	do	E-6		Bored, 4-inch, inside of 7-inch.	74		375+		....	Not raised	200.00		Not used	

1347	Chas. Stanley	do	E-5, 6		Bored, 7-inch	60	58		27		Wind				Domestic; stock	
1348	*Irvine Rancho Co*	*do*	*F-8*		*do*	85			156		*do*				do	
1349	Newport Beach Co	do	D-10	1901	Dug, 12 by 12 foot	2	4—	8	105		Gas		50.00	$450.00	Sewers	
1350	do	do	D-10		Dug, 4 by 6 foot	2	1—	4			Wind				Domestic	
1351	"Boy" Club	do	F-10		Dug, 3 by 4 foot	6	1	7			do				do	
1352	do	do	F-10		Dug, 4 by 4 foot	2	2—	6		68	Hand				Stock	
1354	Newport Beach Co	do	D-10		Bored, 4-inch	2	2	500+			Hand valve				Not used	
1355	do	do	D-10		Dug, 3-foot diameter	2	0	4		67	Wind				Domestic	
1356	M. A. Baker	do	G-5	1904	Hydraulic, 3-inch	48	48		29	72	Artesian				do	8
1358	L. M. Brooks	San Joaquin	M-15	1904	Dug, 4 by 4 foot	75	43	33		62	Hand				Stock	
1359	F. C. Frefren	do	M-15	?1898	Bored, 7-inch	75	10—	97			Wind				do	
1360	L. M. Brooks	do	L-15	1904	Dug, 4 by 4 foot	35	29	12			Hand				do	
1361	J. D. Ponder	do	M-15	1903	do	35	27	12		66	Wind				do	
1362	G. A. Burton	do	M-15		Dug, 3 by 3 foot	55	45	16		65	Hand				do	
1363	Joe Yoch	do	M-15		Bored, 7-inch	50	39	109			Wind				do	
1364	do	do	M-15		Dug, 4 by 4 foot	35	24	18			do				do	
1365	O. Warling	do	M-14		do	50	44	12			do				do	
1366	Mr. Clark	do	M-14		Dug, 8 by 8 foot	75	66	14			do				do	
1369	Mrs. Brown	do	N-12		Dug, 3½ by 3½ foot	225	213	15	174		Hand				Domestic; stock	
1370	Fred Farmer	do	N-12		Dug, 4 by 4 foot	232	231	8	187		Gas				Irrigation	
1371	do	do	N-12		Bored, 7-inch	235	231	22	112	67	Hand				Domestic	
1372	Chas. Rauth	do	N-11		Dug, 4 by 4 foot	350	347	10	52		Wind				Domestic; stock	

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O

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[Water-Supply Paper No. 137.]

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WS 60. Development and application of water in southern California, Pt. II, by J. B. Lippincott. 1902. 96-140 pp.
WS 61. Preliminary list of deep borings in the United States, Pt. II, by N. H. Darton. 1902. 67 pp.
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Correspondence should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

AUGUST, 1905.

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Wells in the Santa Ana quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
1327	Mr. Meyers	Las Bolsas	C-7	.....	Hydraulic, 2-inch	9	9	?90	29	....	Artesian	$32.00	.....	Domestic; stock	.....
1328	John Borchard	.....do	B-7	?1899	.....do	15	15	100+	28	64	.....do	.....	.....	.....do	.....
1329	.....do	.....do	B-7	?1899	.....do	13	13	100+	28	63	.....do	.....	.....	Domestic	.....
1330	W. T. Newlands	.....do	B-7	.....	Bored, 4-inch	17	17	?130	30	66	.....do	.....	.....	Irrigation	.....
1331	J. S. Rice	Santa Ana	D-5	.....	.....do	40	40	192	26	71	.....do	.....	.....	Domestic; irrigation; stock.	.....
1332	.....do	.....do	D-5	.....	Bored, 7-inch	50	50	.....	23	72	.....do	.....	.....	Irrigation; stock	.....
1333	R. J. Webster	Las Bolsas	D-5	1904	Bored, 4-inch	27	27	75	35	65	.....do	.....	.....	.....do	4
1335	J. E. Snow	Santa Ana	D-5	.....	Hydraulic, 3-inch	50	50	182	23	72	.....do	.....	.....	.....do	4
1336	.....do	.....do	D-5	.....	Bored, 3-inch, inside of 6-inch.	50	50	218	24	70	.....do	.....	.....	Stock; irrigation	3
1337	.....do	.....do	D-5	1903	Bored, 4-inch	50	50	?230	22	....	.....do	.....	.....	Domestic; stock	4
1338	.....do	.....do	E-5	.....	Hydraulic, 3-inch	50	50	157	28	....	.....do	.....	.....	Irrigation; stock	2
1339	W. S. Brunton	.....do	E-5	?1899	Bored, 3-inch, inside of 7-inch.	50	50	?200	26	73	.....do	.....	.....	Domestic	†2
1340	Clark Bros. & Babb	.....do	E-5	1886	Bored, 4-inch	50	50	?250	30	....	Wind	.....	.....	Domestic; stock	.....
1341	George H. Clark	.....do	E-5	?1901	Hydraulic, 3-inch	47	47	180	29	....	Artesian	.....	.....	.....do	Small.
1342	.....do	.....do	E-5	1904	Bored, 12-inch	42	42	375+	....	....	.....do	.....	.....	Irrigation	.....
1343	.....do	.....do	E-5	1886	Bored, 7-inch	51	33	265	30	....	Wind	.....	.....	Stock	.....
1344	L. Montgomery	.....do	E-5	1886	Bored, 4-inch	52	52	280	25	....	Artesian	.....	.....	Domestic; irrigation; stock.	†45
1345	Geo. W. Griffiths	.....do	E-5	1892	Bored, 6-inch	52	.....	320	31	....	Wind	.....	.....	.....do	.....
1346	Clark Bros. & Jefferson.	.....do	E-6	.....	Bored, 4-inch, inside of 7-inch.	74	.....	375+	....	....	Not raised	300.00	.....	Not used	.....

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
Washington, D. C., November 3, 1904.

SIR: I transmit herewith a report entitled "The Development of Underground Waters in the Central Coastal Plain Region of Southern California," prepared by Mr. W. C. Mendenhall, under the general direction of Mr. N. H. Darton, and recommend that it be published as a Water-Supply and Irrigation Paper.

This paper is similar to the one just published entitled "The Development of Underground Waters in the Eastern Coastal Plain Region of Southern California," and contains the results of work in the portion of the coastal plain just west of the area described in that paper. A third paper will treat of the area northwest of that here described and will complete the series of preliminary papers on the coastal plain of southern California.

The studies, a part of whose results are being made available in this way, are planned to cover all the important water-bearing lands of the valley of southern California. In most instances the facts gathered concerning the wells and the distributing systems will be supplemented by a study of the local geology, in so far as it controls the amount, distribution, and circulation of the ground waters. The hydrographic data and the geologic data will then be discussed and issued together in one report. In the coastal plain area, however, the geologic conditions being relatively simple, and the hydrographic data being large in volume and of paramount importance, it is deemed best to issue the latter at once, rather than to delay it pending the working out more fully of the comparatively unimportant geologic problems. Therefore the tables and maps are presented here for the consideration of water users, with a comparatively brief text, which is chiefly descriptive, but which includes a discussion of the effects of development and drought in bringing about those changes in water levels and in the outlines of artesian areas which have been most marked within the last five or six years.

Very respectfully,

F. H. NEWELL,
Chief Engineer.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

DEVELOPMENT OF UNDERGROUND WATERS IN THE CENTRAL COASTAL PLAIN REGION OF SOUTHERN CALIFORNIA.

By W. C. MENDENHALL.

INTRODUCTION.

This paper is similar to Water-Supply Paper No. 137, on the "Development of Underground Waters in the Eastern Coastal Plain Region of Southern California." It contains the data gathered by the Survey in the Downey and Las Bolsas quadrangles,[a] just west of the two quadrangles described in the earlier publication. It includes tables of the wells, with data as to their position, depth, diameter, cost of installation, and yield, and maps of the irrigated lands and distributing systems. These data give a résumé of the individual experiences of well owners in the region as well as of the general effects of the great amount of development which has taken place within the last ten years.

By the valley of southern California is meant that lowland area extending from Santa Monica to Redlands, and from the base of the San Gabriel and San Bernardino ranges southward 30 or 40 miles. It includes the coastal plain, the broad portions of the Santa Ana, San Gabriel, and Los Angeles river valleys, and the irregular groups of hills which add picturesque variety to these lowlands and separate them into distinct tillable areas. Much of this region is intensively cultivated. The foothill belt from Pasadena eastward to Ontario, the Riverside Mesa lands, and the Redlands and Highlands benches are justly famous citrus regions, where agricultural lands have high values. In the coastal plain, which is not so well adapted to citrus culture, there is greater agricultural diversity: dairying, market gardening, the raising of deciduous fruits and vegetables and of English walnuts, celery, and sugar beets being important industries.

[a] A quadrangle is the unit of survey adopted by the United States Geological Survey for the topographic and geologic atlas of the United States. It is a rectangular area 15 minutes, 30 minutes, or 1 degree in extent each way, bounded by parallels and meridians, and having an area of one-sixteenth, one-quarter, or 1 square degree. The quadrangles disregard political boundaries, such as those of States, counties, and townships. To each is given the name of some well-known place or feature within its limits. A sheet is the topographic map of one of the above areas.

In all of this agricultural and horticultural activity, the first requisite is water. The entire region is semitropic and semiarid and irrigation is necessary in order to mature any except a few of the less valuable crops. As is generally the case in regions of little rain, the soils are rich because they have not been leached of their soluble fertile elements, and when water is applied to them they yield abundantly. As is fully recognized by agriculturists, constant sunshine and warmth, with the artificial application of water in the right quantities at the right times, give ideal conditions for large yields; hence the lands in arid or semiarid regions, when brought into cultivation by means of an abundant artificial water supply, are much more valuable than those in regions of greater rainfall, where irrigation is not practiced.

In southern California lands under irrigation usually bring several hundred dollars per acre, are not infrequently valued at $1,000 per acre, and may, in exceptional cases, bring $2,000 or even more. Since the greater part of the cultivable dry lands quickly acquire such values when water is applied to them, the story of the growth of this region becomes a story of the utilization and application of its available waters. To the practical solution of water problems, engineering and legal, much of the best talent of the country has been devoted for many years, and will be for many years to come.

The first settlers, the Mission Fathers, after them the Mexicans, and still later the Americans, secured their first holdings near the flowing streams or the "ciénaga" lands, the sites of perpetual springs. As the areas under cultivation slowly increased, the waters of the mountain canyons were gradually appropriated and applied to the adjacent lands. Then engineering devices were resorted to for increasing the flow of springs, for intercepting the underflow of streams, or for storing the flood waters by means of dams and reservoirs. Lastly, attention was turned to the underground waters, which proved to occur in large quantities and to be widely distributed, so that entire communities have sprung up which depend wholly on these sources for their irrigation water. Developments during the last ten years have been chiefly those of underground sources, and the maps and tables in this paper show their extent in a small part of the valley of southern California. (See Pls. I, II, and IV.)

THE COASTAL PLAIN.

The district under immediate consideration is the central portion of the coastal plain of southern California. This plain extends inland from the Pacific Ocean 15 or 20 miles to the base of the hills which represent the Coast Range, and stretches coastwise for 50 miles from Sherman to the foot of the San Joaquin Hills. It is generally level or gently sloping, is fringed on the coastward side by a belt of salt marshes and sand dunes, and has an area of 775 square miles.

THE INNER EDGE OF THE COASTAL PLAIN WEST OF WHITTIER, CAL.

On the northeast it is bounded by the Santa Ana Mountains and their extension, the Puente Hills. Near the Pacific its even surface is interrupted by a line of low hills which, in the vicinity of Huntington Beach and Los Alamitos Bay, lie close to the coast, but which to the northwest are found farther inland as the shore line swings westward about San Pedro Hill. This line of low hills of irregular height marks the seaward boundary of the coastal artesian belt. As a topographic feature it is broken by the valleys of Santa Ana, San Gabriel, and Los Angeles rivers which cross it on their way to the sea; but as a structural feature and as a barrier to the subterranean waters which percolate slowly seaward, it appears to be continuous throughout. The Downey and Las Bolsas quadrangles, which constitute the central coastal plain region, include an area that extends from the shores of the Pacific at San Pedro Bay across the coastal plain to its inner edge in the neighborhood of Whittier and the Paso de Bartolo (Pl. III). These quadrangles lie about midway of the east-west extent of the plain and include the broadest part of the artesian belt; they contain more wells than any area of equal size in southern California.

The greater part of this area is underlain by loose sediments—sand, gravels, and clays—which were brought down from the mountains by the rivers and distributed by them and by the waves and currents of the Pacific off the shore of this part of the continent. The coastal plain is believed to have been at one time a broad embayment with San Pedro Hill as an island well offshore, as Santa Catalina is now. As a result of the accumulation of the débris brought out by the streams, and perhaps also in part as a result of uplift through crustal movement, this great bay has been reclaimed from the sea, and is now a prosperous and, throughout much of its area, densely settled agricultural region.

SOILS AND CROPS.

The soils of the Downey and Las Bolsas quadrangles do not exhibit the great diversity found in some areas of the same size in the southern part of the State, although a number of more or less distinct varieties are recognized and mapped by the Agricultural Department.[a] The soils are rather uniform in texture, ranging only from the sands or fine gravels of San Gabriel Wash or of the beach dunes, to the dark adobes of the marshes and tule lands. They vary in origin from the washes brought by the streams from the distant mountains to the clays of the benches east of Whittier, which are derived from the Tertiary shales of the adjacent hills. They include the rich loams of the peat swamps, which owe their fertility in part to the vegetable

[a] Mesmer, Louis. Soil survey of the Los Angeles area. Field Operations Bureau of Soils, U. S. Dept Agriculture, 1901.

mold which has accumulated through the decay of plant growths. These soils are generally productive, except in the sandy washes or dunes and in some of the lower lands where alkalies are found in excess. The latter trouble probably can be remedied by drainage in all cases, but few systematic attempts have yet been made in this direction. The more alkaline lands are generally included in the wide pastures of the larger undivided ranchos.

The crops exhibit the diversity which is characteristic of the coastal belt. On the benches about Whittier are extensive citrus orchards. In the lowlands, under the San Gabriel irrigation systems, are many flourishing walnut groves and orchards of deciduous fruits. Berry growing, gardening, alfalfa raising, dairying, and grape culture are practiced about Florence and Compton. Sugar beets and alfalfa are raised in quantities in the vicinity of Los Alamitos, and celery, potatoes, corn, and fruits are grown in the fertile and highly cultivated peat-land region south of Westminster.

Large parts of the Los Cerritos, Los Alamitos, and Los Coyotes ranchos are not under cultivation, but are reserved as pasture lands and stock ranges. As these ranchos include considerable areas of moist land, grazing is possible throughout the year over much of their acreage without irrigation.

WATER SUPPLY.

Both the surface and the subsurface waters of the Downey and Las Bolsas quadrangles are supplied largely by San Gabriel and Los Angeles rivers. Part of the underground waters of the southeastern portion of this area are probably contributed by the Santa Ana drainage system. These three streams, the largest in southern California, carry to the Pacific almost all of the run-off from the southern and western faces of the San Gabriel and San Bernardino ranges, which are the most effective mountain masses in this section of the State from the point of view of their capacity to induce precipitation. This is due to their height and to the fact that no high land intervenes between them and the Pacific, whence the moisture-laden winds come.

The channel of each of these streams, in its passage seaward from the mountains, crosses one or more wide valleys filled with loose sands and gravels. The waters are absorbed by this débris, and percolate slowly through it, beneath the surface, to reappear at some lower point where an obstruction to the underground passage forces them to the surface. At these points the underground waters become surface flows again, until absorbed later by another body of loose material. Thus the Santa Ana sinks in the wash above Redlands, rises to the surface above the Bunker Hill "dike," sinks below it, rises from Riverside to Bedrock Canyon below El Rincon, sinks in

the wash above Santa Ana, and finally partly rises again in the large peat-land springs about Talbert. The San Gabriel and the Los Angeles exhibit the same characteristics, but disappear and reappear less often in their much shorter courses to the sea.

This natural habit of the streams has been more or less seriously interfered with by the irrigation systems developed since the settlement of the region. At present irrigation canals head at the mouth of the mountain canyon from which each stream first debouches upon the plain, and at every place where the subterranean waters reappear the water is distributed upon the adjacent lands, where a much smaller proportion of it sinks and joins the underflow than before it was thus diverted.

The winter flood waters, which have always furnished the most important addition to the underground supply, are interfered with but little by the irrigation developments, and are still available for the annual recharge of the gravels.

IRRIGATION SYSTEMS.

The only important system of canals in the Downey and Las Bolsas quadrangles is the one which diverts the San Gabriel River waters that rise to the surface in the neighborhood of the Paso de Bartolo (see Pl. II). A number of ditches here, some of them among the oldest in southern California, take out the river water as it rises in springs, and distribute it over the irrigable lands in the neighborhood of Whittier, Rivera, Downey, and Norwalk.

The available measurements of flowing waters at the Paso de Bartolo are as follows:

Discharge measurements at the Paso de Bartolo.

	Discharge.		
	Aug. 7, 1900.	Oct. 2, 1903.	Oct. 5, 1904.
	Second-feet.	*Second-feet.*	*Second-feet.*
Sheep Creek ditch	2.46	4.6	1.35
Rincon ditch	2.47	3.4	1.5
Old Temple ditch	1.20		
Cate ditch	8.71	5.5	11.1
Standefer ditch	14.56	14	12.9
Banta and Los Nietos ditches	15.44	28	19.5
Rio Hondo under Mission bridge	23.18	29	22.19
Baldwin's ditch			2.89
Total	68.12	84.50	71.43

It is to be expected that October measurements will be higher than those of August, the evaporation being lighter in the fall, but the effect of the greater rainfall preceding the summer of 1903, as compared with the summer of 1904, is clearly shown in the difference between the two October measurements. None of the waters measured are developed waters, and none of them reach the pass as surface streams. All represent underflow below the mesa lands north of the pass, forced to the surface by the constricted character of the outlet and the comparative nearness of bed rock to the surface.

The following brief descriptions of some of the principal ditches which take their supply from this region and distribute it over the irrigable lands south of the pass are summarized in part from William Ham. Hall's "Irrigation in Southern California." They are brought up to date by additional information gleaned from various sources.

RINCON DITCH.

This ditch is nearly 6 miles long and takes its water from San Gabriel River about 2 miles below the Southern Pacific Railroad crossing. It was built by Mr. Strong in 1871. It is about 4 feet wide on the bottom, unlined except in the vicinity of the pumping plant, and carries a variable depth of water. The land which it serves lies in the Paso de Bartolo and along the upper edge of the coastal plain just west of Whittier. In 1888 about 586 acres were reported as served by the ditch, and in 1904, 800 acres. In 1902 the supply of water from the river was augmented by the installation of a pumping plant, which is now used to make up the deficiency in the river supply. In 1904 this plant was in operation for about four months, day and night, and produced during that time about 120 miner's inches. The pumping company is incorporated as the Rincon Irrigation Company, but its stockholders are the irrigators owning land served by the ditch.

CATE DITCH.

This ditch, built by J. W. Cate in 1867, takes its waters from the San Gabriel at about the point where the stream deserted its old channel in the flood of 1867–68. The ditch is about 3¾ miles long, and serves an area lying in and below the Paso de Bartolo and between Rio Hondo and San Gabriel River. The amount of land irrigated by this ditch has remained nearly constant, for 1,200 acres were reported under irrigation in 1880, 1,300 acres in 1886, and 1,300 acres in 1904. Until 1900 the ditch was of earth construction and the loss of water by seepage was considerable. On April 19 of that year the water users incorporated as the Cate Ditch Water Company, with 3,600 shares at $1 per share. Money was borrowed and improvements were at once undertaken. At present (January 1, 1905,) one-half mile at the head of the ditch

and 1 mile at the lower end of the ditch remain unimproved, over 2 miles are cemented, and 1,000 feet of wood flume have been put in. These improvements are reported to have cost about 50 cents per running foot. The water stock is appurtenant to the land and is nontransferable. The thirty-five irrigators are assessed $1 per acre to cover running expenses and interest and to provide a sinking fund. The expenses are low, the cost of repairs on the dam and charges for cleaning, improving, and maintaining the ditch amounting to only about $350 annually.

When water is abundant in the spring the ditch is divided into three heads; in the summer, when the amount available is less, but two heads are available, and at times of particularly low water there is only enough for one head. A "head" under these conditions is a variable quantity, but is said always to exceed 100 miner's inches. The period of rotation varies from twelve to sixteen days. Each irrigator in turn has the use of a head of water for thirty minutes per acre, except when the ditch carries but one head, when the period is reduced to fifteen minutes.

The available measurements of the flow in the Cate ditch follow:

Flow in Cate ditch, California.

	Miner's inches.[a]
August, 1900	435
October, 1903	275
October, 1904	555

STANDEFER OR RANCHITO DITCH.

This ditch was constructed in 1871 by settlers who had purchased lands on the Paso de Bartolo Rancho from Pío Pico. Its title is inherited by prescription and riparian ownership from the rancho, whose proprietors had used the water, although in a very unsystematic way, for years. The diversion from the San Gabriel is by a sand and brush dam, owned and constructed by the Standefer, Banta, and Los Nietos ditches jointly, at about the narrowest part of the pass. The main ditch is over 3 miles long and discharges into San Gabriel River below the Santa Fe Railroad. During the past two or three years the Pallett and Walnut branches and about 2,800 feet of the main ditch have been cemented. The rest is of earth construction. In 1902 the irrigators under this ditch incorporated on a basis of 10 shares per acre, or 13,000 shares in all. The expenses of cleaning and maintenance, zanjero's fees, etc., are met by charges of 10 cents per hour per head for day service and 5 cents per hour for night service. The ditch carries three or four heads of 150 to 200 inches. Charges for new construction, cementing, etc., are met by special assessments.

[a] The old California miner's inch is used throughout this report. It is equivalent to 9 gallons per minute, one-fiftieth second-foot, or 14.478 acre-feet per year.

BANTA AND LOS NIETOS DITCHES.

The Los Nietos ditch, which was built previous to 1838 by Don Pío Pico, the grantee of the Paso de Bartolo rancho, and the Banta ditch, built by P. Banta in 1867, have used the same canal for about 2 miles below their diversion works since 1884, when the original upper Los Nietos ditch was destroyed by flood. Below the section which is owned and operated jointly, the Banta ditch is about 2 miles long and serves about 800 acres southwest of Whittier and below the lands watered from the Rincon ditch. Twenty-three irrigators are served by this ditch at present (1904).

The Los Nietos ditch extends south about 3½ miles from the point of its diversion from the Banta ditch and serves about 1,000 acres lying just east of San Gabriel River. In 1885 its interests were incorporated on the basis of 1,500 shares, which are not transferable out of the district.

The total flow in the San Gabriel at the headworks of the Standefer, Banta, and Los Nietos ditches, which was estimated at from 1,200 to 1,500 miner's inches in 1888, is proportioned among the three ditches in the order named in the ratio of 12:9:7, the division being effected on the following basis: The total flow is divided into four parts, each ditch receiving one part and the remaining fourth being shared by the Standefer and Banta ditches, the former receiving the water five and the latter two days in each week.

The combined flow of the two ditches on August 7, 1900, as determined by S. G. Bennett, was 772 inches, and on October 2, 1903, as measured by W. B. Clapp, was 1,400 inches. October 5, 1904, Mr. Clapp reported 975 inches at the headworks.

ARROYO DITCH.

This ditch takes its supply from Rio Hondo, about 2 miles below the pass, and serves a large district lying east of this stream and west of the territory supplied by the Standefer ditch and its extensions.

The canal was built in 1869 and succeeded an earlier crude ditch which was really an old arroyo into which water had been diverted. The title is inherited from the riparian rights of the Rancho Santa Gertrudes, but no systematic attempt was made to use the water prior to the subdivision and sale of the rancho by Governor J. G. Downey in the late sixties.

In 1885 the irrigators organized the Arroyo Ditch and Water Company, which was incorporated with a capital stock of $22,500. Before this time more or less indefinite attempts at organization had been made, but they were only partially successful. Indeed, about fifteen irrigators owning lands near the head of the ditch finally refused to join in the incorporation, but successfully defended their right to the

use of their proportion of the water. At this time there was much internal dissension among the various irrigators supplied by it.

The total length of the main line from the intake below the pass to the terminus, 1½ miles south of Downey, is about 7 miles; the Sand-ridge branch, which leaves the main ditch at the crossing of the Santa Fe Railroad, is about 4 miles long.

In 1888 the ditch was reported to have a minimum supply of about 1,200 inches, and to serve about 3,800 acres. The acreage supplied by it has varied but little, being about 4,000 in 1871 and in 1903. The flow of Rio Hondo at the Mission bridge, all of which is diverted below into the Arroyo ditch, is reported by W. B. Clapp as follows:

Flow of Arroyo ditch, California.

	Second-feet.
August, 1900	23.18
October, 1903	29
October, 1904	22.19

SAN ANTONIO DITCH.

This ditch is supposed to serve a few hundred acres lying west of Rio Hondo and midway between the Southern Pacific and Santa Fe railroads. It uses the upper part of the Arroyo ditch, and later delivers 135 inches of water to the Gage ditch. It is of sand and earth construction throughout, is poorly cared for, and choked with weeds, so that little or no water is actually delivered to the lands served.

The water at the head of the Arroyo ditch was originally divided equally between that ditch on the one hand and the San Antonio and the Foster, or Gage, ditches on the other, the right of the Foster to 135 inches being acknowledged.

The Arroyo Ditch Company at an early day improved the upper part of its canal and thereby effected a saving of 100 inches. As the San Antonio Ditch Company declined to share in the cost of this improvement, the water saved went to the Arroyo ditch in accordance with the terms of an agreement entered into in 1885. Recently further improvements have resulted in an additional saving, also claimed by the Arroyo Ditch Company, which has borne the expense of the improvements.

The title to this last increment, however, is not admitted by the San Antonio Company, and the matter is not as yet finally settled.

The basis of division now is this: The first 100 inches belongs without dispute to the Arroyo Ditch Company, and the first 235 inches is claimed by them. The remainder is divided equally between the San Antonio and the Gage ditches on the one hand and the Arroyo ditch on the other. Of the first part 135 inches is assigned to the Gage ditch. The part remaining after this is taken out belongs to the San Antonio ditch, but as it flows for 2 miles through the sandy bed of Rio Hondo a large part of it seeps away and is lost.

OTHER DISTRIBUTING SYSTEMS.

In addition to these principal ditches which have been mentioned, the Little Lake ditch, the Section Line ditch, the Agricultural ditch, and the New River ditch represent lower diversions from the San Gabriel, which receive such excess as may be left after the older rights are satisfied. Their supplies are received chiefly in the winter season.

The town of Whittier secures its domestic supply from two wells just east of San Gabriel River, on the Whittier-Los Angeles road. The water is pumped from these wells into a reservoir on a knoll above the village, whence it is distributed by gravity.

Long Beach and Los Alamitos Beach are supplied by flowing wells in the artesian basin, north of Signal Hill.

Part of the Long Beach supply reaches the town by gravity from the vicinity of Bixby station; another portion flows into a reservoir and is pumped thence into higher reservoirs on Signal Hill, whence it is distributed. This latter plan is followed by the Alamitos Beach Water Company.

Another important line not yet mentioned is that owned by the East Whittier Water Company. The water supply in this case is not secured from the water-bearing lands of the coastal plain but from the San Gabriel Valley, north of the Paso de Bartolo, near Woyden Station, on the Southern Pacific. A well-equipped air-pumping plant has been installed here and coupled with a number of wells. The water thu developed is conveyed by flume, covered ditch, and cement and steel pipe lines to the lands served in the East Whittier and La Habra districts. This system of covered and lined canals throughout is an example of a modern up-to-date distributing plant.

DRAINAGE DISTRICT.

In Water-Supply Paper No. 137, on the underground waters of the eastern coastal plain region, the Bolsa and the Willows drainage districts of the peat lands of Orange County have been briefly described. The greater part of the older of these two districts, the Bolsa, is on the Las Bolsas quadrangle. Its outlines are shown on Pl. II.

The earliest ditch in this district is reported by Mr. W. B. Lamb to have been dug twenty or thirty years ago by the Stearns Rancho Company. Later the county improved and extended this original ditch, and finally, in 1899, the Bolsa drainage district was organized under a State law passed two years before.

Under this law three commissioners were elected especially to make a levy upon the district for the maintenance and extension of the ditch. These commissioners levied $15,000 for the expenses of the first ten years, but the amount will not prove sufficient, and an additional levy is expected within a year or two. The expenditures each

year are determined by a board of three directors elected to serve two years. They decide year by year the amount of the original levy that is to be expended. When this annual levy has been determined, it is collected by the county from the landowners within the districts, and the expenditures are then paid by warrants drawn upon the county treasurer.

About 15 miles of ditch are reported within the district, and the annual maintenance charges, exclusive of new construction, are given as about $1,000. Several miles of private drain have been put in, with outlets in the main ditches. The land has thus been greatly improved, until now the district contains some of the most valuable of the famous Orange County peat lands.

UNDERGROUND WATER.

SOURCES.

The chief supply for the underground as well as for the surface waters of the Downey and Las Bolsas quadrangles comes from Los Angeles and San Gabriel rivers, both of which flow across the Downey quadrangle; another portion of it is probably furnished by Santa Ana River, whose surface channel lies entirely to the east of this area, but whose percolating subsurface waters may contribute to the underground supply in the Las Bolsas quadrangle and in the southeastern part of the Downey quadrangle. An unknown, but no doubt minor, amount is contributed by the summer underflow of these streams, and that part of the surface flow that is not lost by direct evaporation or by transpiration through the plants, in the process of irrigation for which it is all utilized, also becomes available. This proportion of return water must vary greatly with locality, soil, and manner of irrigation. On the mesa lands, whose soils are warm and dry and are often underlain by an impervious hardpan, and whose water supply is expensive and never used in excess, the proportion of return waters must necessarily be small. On the other hand, on the sandy lands between San Gabriel River and Rio Hondo, where water is applied in abundance, sometimes in excess, upon a sandy absorptive soil, the return must be large; here it is probably much more than the 30 per cent which is often assumed as the proportion of return waters. A third minor source of supply is the light surface and subsurface drainage from the adjacent slopes of the Puente Hills. This yields a relatively small amount. The winter season is the period of most effective restoration of the subterranean supply. The direct rainfall upon the coastal plain averages approximately 12 inches, almost all of which falls at that time; but the most important sources are the flood waters of the streams and the usual normal winter flow, a smaller proportion of which is utilized for irrigation when the rains reduce the necessity for the latter.

As these flood waters pass over the sandy washes they are absorbed rapidly and are thus added to the underground stores. A proportion of the greater floods often escapes absorption by reaching the sea over the surface. It is thus wholly lost.

In considering the sources of these underground waters there may be dismissed at once the suggestion that the sea water, by some great extension of the power of capillarity, is drawn inland and freed of its salt, or that a portion of the waters of Colorado River, or some equally distant stream, flows in an underground channel through the great intervening mountain barriers. These theories have no basis in fact, and are generally expressions of wishes rather than of sober belief.

DISTRIBUTION OF UNDERGROUND WATER.

Since the coastal plain is underlain by irregular sheets of more and less pervious material—gravels, sands, and clays—which slope gently toward the sea and increase in coarseness inland, the underground waters that percolate seaward along the coarser beds are often caught beneath a less pervious layer and accumulate pressure from the weight of the water behind them. A bed of open material may wedge out seaward between impervious strata, or may abut against an earlier ridge, or may, with the beds above and below it, be folded into an anticline, or may become gradually finer and less permeable seaward, so that the escape of its waters in that direction is cut off or rendered less easy than their entry farther inland. Under these conditions, whenever the overlying confining stratum is penetrated by a pipe or a drill, the confined waters tend to rise to the level of their source. This is the general explanation of the artesian conditions which exist here.

Since the percolating waters gravitate seaward and the finer beds, which are as essential to artesian conditions as the coarser, occur more often along the lower portion of a stream's course, it follows that the artesian areas are in the lower parts of a basin distant from canyon mouths, where only comparatively coarse detritus is deposited. All of the southern California streams are alternately surface and subterranean, the Santa Ana, San Gabriel, and Los Angeles each disappearing and reappearing several times between the mountains and the sea. The area in which the surface channels, during the summer seasons at least, are dry, is always a wide valley region; while the waters flow on the surface either in canyons, where bed rock is near the surface, or in open plains, where there is an effective, if inconspicuous, obstruction to the subsurface circulation.

Near the lower edge of practically every lowland in the valley of southern California across which a stream flows is an artesian basin, large or small, whose existence is due to conditions like those just outlined. After the waters escape from one such basin and flow

over its lower rim, the conditions are duplicated in the next basin below, and artesian waters are again found there. Thus, the waters of the Santa Ana first pass through the San Bernardino artesian belt. They escape over its lower rim, the "Bunker Hill dike" above Colton, and again sink and enter the small and unimportant Riverside basin. At Riverside Narrows they are forced out by the proximity of bed rock, flow over the surface through the lower Santa Ana Canyon, and finally enter the coastal plain artesian belt. At a point farther north than the mouth of the Santa Ana, where a wider strip separates the lower edge of the coastal plain artesian area from the Pacific, waters from this belt again occur under pressure in the small Ballona artesian area near Playa del Rey (Pl. I).

Where other conditions, such as amount of water available, are equal, those artesian basins which exist along the upper portion of a stream, though smaller, should be more efficient than the basins lower down, since near the source of the débris the water-bearing strata are usually coarser and more abundant. Such coarse strata yield their water more readily, giving wells of greater flow, and are replenished more quickly after exhaustion because they absorb flood waters with greater rapidity. At such a higher point, however, conditions are less favorable for the widespread deposition of the fine, relatively impervious clays, which are as essential as the coarser beds to the existence of artesian basins, hence the higher artesian basins are apt to be less extensive than those farther downstream, although they yield water more readily and are therefore perhaps more likely to be exhausted by reckless development.

The coastal plain artesian basin is much the largest of a number of basins which occur at various points between the sources and the mouths of the rivers of this part of southern California. It is in fact a union of the lowest basins of the three principal streams of this part of the State. Its area at present (August, 1904) is about 190 square miles. Originally it was somewhat less than 300 square miles. A large part, both of the present and of the original coastal belt, is included in the area treated in this report—the Downey and Las Bolsas quadrangles. There are now approximately 121 square miles of artesian water-bearing lands in this area, 105 square miles in the Downey quadrangle, and 16 square miles in the Las Bolsas quadrangle (Pl. IV).

There has been no decrease in the artesian area in the Las Bolsas quadrangle, because it lies along the lower edge of the artesian lands, the last portion to be affected by dry years or by excessive drafts. The artesian area in the Downey quadrangle has decreased 45 square miles, or 30 per cent from the original 150 square miles. The southwestern seaward edge of this basin is marked by a low, irregular ridge, whose highest point, Los Cerritos, 2½ miles northeast

of Long Beach, is 364 feet above sea level. Dominguez Hill, another prominent point west of the channel of Los Angeles River, has an elevation of 195 feet. Toward Huntington Beach the ridge is lower and indeed is entirely cut away for several miles by the outlets of San Gabriel River, Anaheim Creek, and Bolsas Creek, so that along the coast between Los Alamitos Beach and Huntington Beach only isolated knobs, like Landing Hill, Bolsa Chica, and Las Bolsas exist as surface expressions of the underground structure that acts as a barrier to the subterranean waters in their slow movement seaward.

Beyond the artesian area, both north and south, are broad belts in which the water is not under sufficient pressure to flow but is near enough to the surface to be readily available for pumping. Such belts include areas that were originally artesian. They extend, on the one hand, to the base of the Puente Hills or to the northern edge of the Downey quadrangle, and on the other, practically to the shores of the sea. The position of the surface of the zone of saturation throughout the areas where the ground water is important as a source of supply is shown on Pls. I and IV by means of contours drawn upon that surface as a plane. The depth to the ground-water level at any point may be determined by subtracting the altitude of the ground-water level, as shown by the hydrographic contours, from the altitude of the surface, as shown by the topographic contours.

DEVELOPMENT OF UNDERGROUND WATER.

In the Downey quadrangle there are more than 3,000 wells, all of which draw to a greater or less extent on the underground supplies. In the adjacent Las Bolsas quadrangle there are 300 wells. Of this total of 3,300, 175 are equipped with pumping plants operated by electricity, steam, or gasoline. These plants represent an investment of about $150,000, and the wells upon which the pumps have been installed have cost about $75,000; the pumped wells and their installation, therefore, represent a capital of $225,000.

Of the 3,300 wells, about 1,635, nearly one-half, were artesian in the spring of 1904, and their estimated cost—the estimate being based on reports from about 800—was $400,000.

There are about 700 windmill wells in the area, which, with the mills with which they are equipped, represent an outlay of approximately $200,000. The 790 domestic wells that make up the balance of the 3,300 must bring the total capital invested in wells and equipment in the Downey and Las Bolsas quadrangles to the neighborhood of $1,000,000. This is independent of the money invested in ditches, pipes, or other devices for the distribution of the water for irrigation.

A. TYPICAL 10-INCH WELL.

B. WELL NO. 94, DOWNEY QUADRANGLE.

The possible yield of these wells is very large. The output of the pumping plants when in service, based upon the measured or reported yield of five-sixths of their number, is 265 second-feet. The flow from 685 of the 1,635 artesian wells is over 200 second-feet, an average of about 15 miner's inches to each well. If this average is maintained by each of the 1,635 wells, the total yield approaches 500 second-feet, and the combined capacity of the pumping plants and artesian wells exceeds 750 second-feet, or 37,500 miner's inches. It is difficult to estimate how much of this yield is actually used. The pumping season varies from fifty to one hundred and twenty-five days usually. As artesian water is cheaper than pumped water it is used more freely, and many wells flow unchecked throughout the year. Others are open only during the actual irrigating season. On the whole it is considered conservative to estimate that the yield of 750 second-feet is maintained for two or three months of the twelve, equivalent to a continuous withdrawal of developed water amounting to from 125 to 200 second-feet throughout the year from the 268 square miles of the coastal plain which are included in the Downey and Las Bolsas quadrangles.

EFFECTS OF DEVELOPMENT OF UNDERGROUND WATERS.

This development, which began in a small way forty years ago and has continued at an accelerating rate since, the increase in the number and aggregate yield of wells having been particularly marked during the last decade, must inevitably affect the quantity of water in the underground reservoir from which the wells draw.

Before development began the outlines of the artesian basin and the ground-water level expressed a condition of balance between the supply and the natural drainage at that time. With any marked increase in supply, such as may have been brought about by a series of years of excessive rainfall, the ground-water level would rise, increasing the flow from all sources fed by it, and the artesian area would expand and pressure within it would increase, thus increasing the yield of those springs and streams whose sources were artesian waters, until this increased discharge balanced the temporarily increased supply, and a condition of stability resulted. Similarly, during a series of dry years the ground-water level fell and the artesian area contracted, until drainage declined to an equality with the decreased supply. Thus ground-water levels and artesian areas varied within certain limits previous to the change in conditions brought about by development. But with the appearance of man upon the scene, disturbing elements were introduced. The first change in natural conditions consisted of the diversion of the normal summer flow of

streams, which before the diversion sank and added their volume to the stored subsurface waters. A part of this flow, it is true, was added to the underground supply after diversion in the form of return waters from irrigation, but the amount thus added, while a variable proportion of the original, is always distinctly a minor part of it. It may be roughly estimated to run from 5 to 50 per cent of the whole. Thus the supply was sensibly diminished. Meanwhile, the boring of numerous wells in the artesian area increased the freedom of drainage. This factor at a later stage of development was rendered more important by the installation of pumping plants outside of the artesian belt. The water secured by these means, like that secured by stream diversion, was largely used for irrigation and a portion of it thus returned to augment the ground-water supply. Yet transpiration through the plants and evaporation in the ditches, and especially from the soil surface in the process of irrigation, dissipates the greater part of the water thus applied.

These two disturbing elements -the decrease of supply and the increase of drainage through development- must destroy the balance reached before they were introduced, and bring about a readjustment of the ground-water level and a rearrangement of the outlines of the artesian areas. Since they both operate in one direction, namely, to lessen the amount of ground water, the readjusted water level must stand at a lower point than the original level, and the new outlines of the artesian area must be within the original outlines.

PERMANENCE OF UNDERGROUND-WATER SUPPLY.

The entire coastal plain, underlain everywhere by saturated sands, gravels, and clays, has an extent of 775 square miles. Under about one-fourth of this area the waters are under pressure and are artesian. The thickness of these saturated gravels is unknown, but wells more than 1,300 feet deep near the inner edge of the plain fail to reach bed rock. It is safe to say that over much of the area their thickness must be expressed in thousands rather than in hundreds of feet. There can be no doubt that practically all of this mass is saturated, so that the total amount of water which exists there is enormous. Its sole source is the rainfall within the drainage basins tributary to the coastal plain, but the gravels themselves and the water saturating them have accumulated during long periods, and since the waters always have been supplied much more rapidly than the gravels they move slowly through as well as over these from an intake along the inner edge of the coastal plain and along the washes of the streams to an outlet at a lower point nearer the coast. The underground waters then are not in any sense lake-like; they simply

fill the voids in the gravels, sands, and clays, and move at varying rates through these voids, under the impulse of gravity and pressure from a constant if varying supply received chiefly at the inner edge of the plain. This continuous movement seaward checks any tendency of the sea water to move inland. It is indeed so completely paramount that it is probable that wells sunk into the sea floor, at short distances off the coast, would at many points yield fresh water, and probably fresh-water springs discharge into the sea at numerous localities.

While the total amount of water underlying the coastal plain then is large, only a small portion of it can be made available for purposes of irrigation. Only that part which is sufficiently near to the surface to pump at a profit, say within 250 feet, or which, although found at a greater depth, will rise under artesian pressure to or near to the surface, can be utilized. Obviously this useful surface zone is most sensitive to diversions of the supply, or to any of the forms of drainage which are included in the general term 'development." No matter from what part of a reservoir the water may be drawn, the surface will be lowered; hence the fact that an enormous quantity of water is stored beneath the coastal plain has no particular bearing upon the practical aspects of the case. The amount of water within reach and the rate of its withdrawal and replenishment, not the total amount existing, are of moment to the water user. Thus in this discussion the exhaustion of the underground supplies means the lowering of the water level until the cost of pumping absorbs all the profits from the crops raised and so becomes prohibitive.

With the original ground-water level and the original outlines of the artesian basin in the Downey and Las Bolsas quadrangles, there was but little if any of the valley or mesa land which did not have water within easy reach. With the shrinkage of the artesian belt, a broad zone along the north edge of the Downey quadrangle in which water originally flowed, was thrown into the pumping zone. Water here now has to be lifted and there is a tendency to complain because of the increased cost and trouble of this method. The general effect is excellent, however, because there are few artesian wells which are not misused. This cheap form of water induces carelessness, almost invariably more water is applied than is needed, and the result is not only a loss of water but injury to the land. With the more costly pumped water, greater care is exercised in its application. It may be stated, then, that throughout the zone originally artesian, but no longer so, a marked saving has been effected in the amount of water used, even where the acreage under irrigation has not diminished.

The rate of the general lowering of the water plane throughout the central coastal plain belt and the accompanying contraction of the artesian area have of course been accelerated by the series of dry years from 1893 to 1900, and by the moderate rainfall slightly below the average since. In consideration of the fact that all of the changes in natural conditions which are due to man's use of water have tended to reduce the supply and so to disturb the balance, of which the original artesian outlines and the original ground-water level were the expression, it must be concluded that a part at least of this lowering and contraction is due to development and is permanent.

Furthermore, so long as the new developments result in adding to the amount of water produced in a given area, the decline must continue. With the decline, springs decrease in yield or cease to flow, artesian wells fall off in output, and pumping plants are used more sparingly, because the water has become more expensive, so that finally the decrease in the amount of water secured by these means reduces the output to an equality with the supply. Then a new balance is reached, and the water level no longer falls. The point at which this new balance is reached depends upon the amount of development. The greater this amount the lower the water level will fall.

The rate of this lowering, even under the influence of the great development which has taken place in the coastal plain, especially within the last decade, has been very slow, even during the dry years, and will be still slower during years of average rainfall, because the body of water drawn upon is so great and the accessions from floods and return waters so nearly balance the withdrawals. It will not continue indefinitely if development ceases now, because the drafts decrease as the water plane lowers and the artesian area shrinks, and probably in part because with the drainage of the gravels the absorptive capacity is increased, so that a smaller proportion of the occasional floods escapes over them to the sea. But the shrinkage which is now in progress and which is expected to continue intermittently for some years, being interrupted by periods of partial restoration during winters of unusual rainfall, does not affect all parts of the coastal plain alike. Always those parts of an artesian belt which lie nearest its lower edge are affected last and least by the shrinkage. Wells will continue to flow here after they have ceased elsewhere, and pressures will be maintained here after they have seriously diminished at other points. It is probable that in so large a basin as that of the coastal plain some of these most favorably located wells will never cease to flow.

The favored places for tapping the ordinary ground waters are not distributed exactly as are those for tapping waters under pressure. Ground water will always be found near the surface, just above the upper edge of an artesian area, but in addition it is not infrequently found within easy reach near the source of supply for a basin, as just below the Paso de Bartolo, while the decline is greatest in some intermediate region. If ground water remains close to the surface near the intake of a basin, while its levels are generally lower in other localities, it is because there is some obstruction below the body of ground water which holds up the percolating moisture for a time. Such an obstruction may be a bed-rock shelf, extending out from near-by bed-rock hills, or it may be only a body of fine clay or dense alluvium.

Declines will likewise be greater in the immediate vicinity of developments, unless those developments are along a line of strong underground flowage, in which case the effect of intercepting this flowage may be more marked at some point below, which is supplied by it, than in the immediate neighborhood of the intercepting wells. In the relatively fine sands and gravels of the coastal plain, however, through which the water probably percolates ordinarily at a rate of less than 25 feet per day, the effect of a battery of pumps must be to draw out the near-by water more rapidly than it is replaced by the slow inflow and thus to lower the water plane locally to a marked degree. With the cessation of pumping, this zone is filled again by infiltration from the surrounding saturated gravels, the effect being finally to spread the depression in the water plane over an area so wide that it is no longer measurable.

A continuous series of observations upon the fluctuations in the ground-water level has not been maintained at any point in the area under discussion, but at Anaheim, a few miles east, systematic records have been kept since February, 1898, by Mr. J. B. Neff. These are of great value for comparison with rainfall records, and when so compared throw much light upon the relative importance of development and drought in bringing about the decline in water levels which has been so generally observed throughout southern California during the past decade.

Rainfall, in inches, at San Bernardino, Cal.

Year.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.
1870 71	0.00	0.00	0.02	0.09	3.11	0.80	6.91	2.21	0.19	0.34	0.11	0.07	13.94
1871 72	.00	.04	.13	.60	.88	3.91	.00	2.20	.37	.79	.06	.00	8.98
1872 73	.00	.18	.04	.00	1.17	4.40	6.50	1.25	.51	.84	.21	.00	15.19
1873 74	.00	1.06	.02	.01	.74	5.73	5.51	8.76	1.08	.48	.42	.00	23.81
1874 75	.00	.00	.06	1.82	1.88	2.20	7.30	.15	.22	.07	.05	.00	13.65
1875 76	.00	.00	.00	.00	7.50	.02	6.55	1.92	3.41	.44	.03	.03	19.90
1876 77	.00	.00	.00	.20	.40	.00	3.50	4.03	.83	.26	.30	.00	9.52
1877 78	.00	.00	.00	.86	.50	3.95	3.33	6.68	2.57	1.71	.66	.07	20.33
1878 79	.07	.00	.02	.14	.05	4.70	3.59	1.00	.50	1.20	.24	.03	11.54
1879 80	.11	.02	.01	.94	3.40	6.50	1.56	1.33	1.45	5.00	.04	.00	20.36
1880 81	.00	.00	.00	.14	.67	8.80	1.40	.36	1.06	.46	.01	.00	13.50
1881 82	.00	.00	.00	.80	.27	.50	1.11	2.65	3.30	2.91	.00	.00	11.54
1882 83	.00	.00	.00	.10	.15	.45	1.60	1.10	2.82	2.95	.00	.00	9.17
1883 84	.19	.00	.53	.85	.09	2.63	1.63	12.20	9.95	5.68	3.17	.59	37.51
1884 85	.00	.00	.00	.00	.11	3.75	2.79	.11	.28	1.89	1.69	.19	10.81
1885 86	.00	.00	.00	.39	4.36	1.20	6.34	2.52	4.18	2.36	.32	.16	21.83
1886 87	.00	.00	.00	.00	.11	.61	.39	6.44	4.41	1.90	.42	.22	14.50
1887 88	.11	.01	.09	1.17	2.29	1.91	4.01	3.60	3.41	.58	.52	.03	17.76
1888 89	.00	.00	.00	.05	4.12	4.64	.93	1.50	6.55	2.05	1.13	.00	20.97
1889 90	.17	.63	.11	2.30	2.23	10.85	5.44	2.52	.89	.00	.31	.00	25.45
1890 91	.13	2.16	.88	.58	1.27	3.02	.00	7.78	.06	.53	1.67	.00	18.08
1891 92	.00	.91	.93	Tr.	Tr.	1.67	3.24	3.30	1.75	.37	2.10	.08	14.35
1892 93	.00	.00	.00	.16	1.02	2.23	4.53	3.37	8.00	.48	.03	.00	19.82
1893 94	.20	.00	.05	1.05	.30	2.28	1.26	.88	1.15	.40	.56	.00	8.13
1894 95	.00	.16	.37	.15	.00	7.25	7.39	1.14	3.44	.64	.44	.00	20.98
1895 96	.00	.00	.00	.00	1.14	.66	2.02	.00	2.92	.37	1.00	.00	8.11
1896 97	Tr.	.17	.00	2.10	.98	1.09	3.40	5.40	3.41	.08	.11	.00	16.74
1897 98	Tr.	.00	.13	2.10	.21	.57	2.10	.60	.97	.48	1.08	.00	8.24
1898 99	.00	.00	.00	.03	.05	.11	2.03	.51	3.22	.07	.19	.95	7.49
1899 1900	.00	Tr.	.01	.81	1.47	.84	.92	.00	.92	1.96	1.71	.00	8.64
1900 1901	.31	.00	.23	.46	6.10	.00	3.48	1.58	.43	.56	1.23	.05	17.36
1901 2	.00	.27	.07	1.09	.28	.01	1.65	3.02	3.89	.57	.12	.15	11.15
1902 3	.07	.00	.00	.00	1.91	1.91	1.96	1.67	6.47	3.10	.24	.00	17.42
1903 4	.00	.15	.16	.07	.00	.00	.18	2.21	5.31	.80	.16	.00	9.37

Average, thirty-four years, 15.05 inches.

Since the rainfall which is most efficient in supplying the surface and subsurface waters of the coastal plain is that which falls in the mountains in which Los Angeles, San Gabriel, and Santa Ana rivers rise, the Los Angeles and the San Bernardino rainfall charts are of more value for purposes of comparison with the profile of the water level than the Anaheim record, which indicates coastal conditions.

Each of these records shows that during the past eleven rainy seasons there has been a marked deficiency. For seven of the eleven this deficiency aggregates about 52 inches at Los Angeles and

about 45 inches at San Bernardino, while the other four years give excessive precipitations of 12 inches at San Bernardino and 7 inches

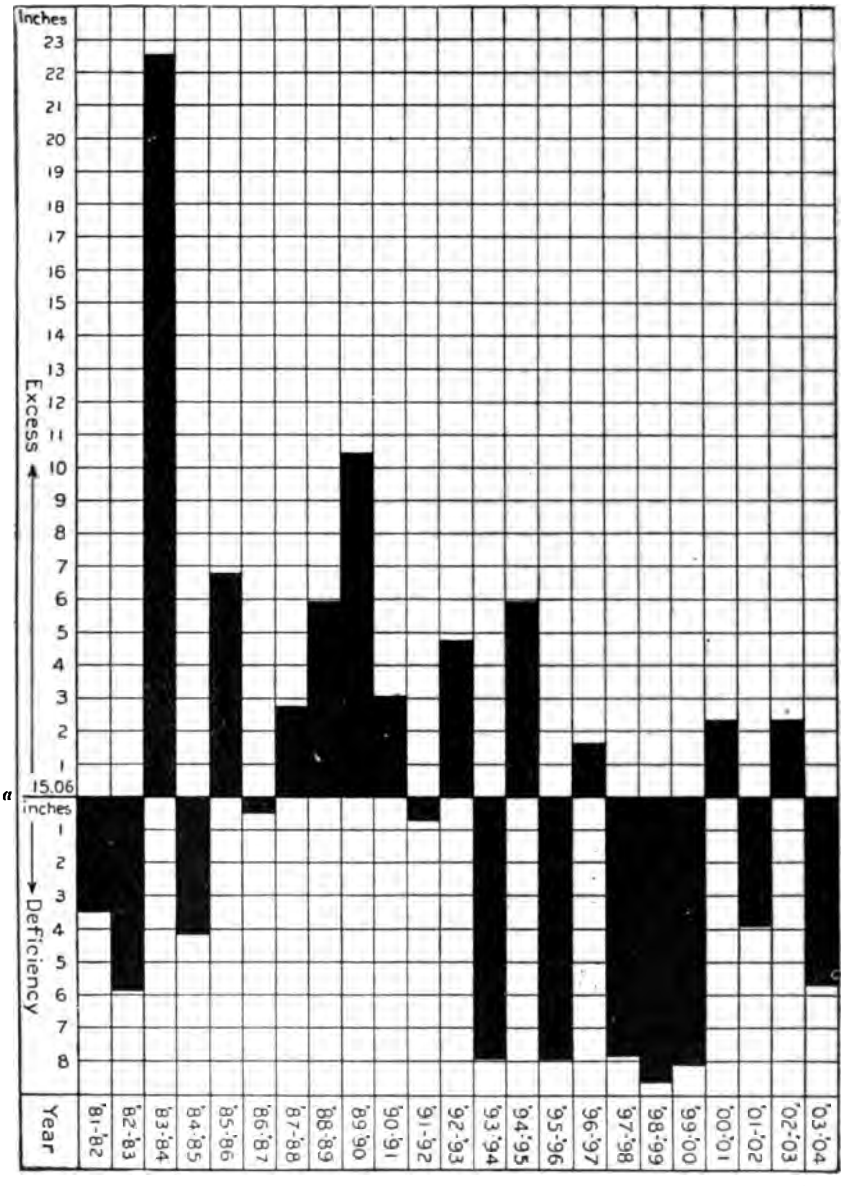

FIG. 2.—Chart showing departures from average rainfall at San Bernardino, Cal. a Average for 34 years (15.06 inches).

at Los Angeles. The average deficiency during the period, therefore, has been about 26 per cent at Los Angeles, 20 per cent at San

Bernardino, and 11 per cent at Anaheim. So marked a falling off in rainfall is in itself sufficient to account for much shrinkage in the ground waters, hence a general decline in water levels is not surprising.

Rainfall, in inches, at Los Angeles, Cal.

Year.	July.	Aug	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.
1877–78	0.00	0.00	0.00	0.86	0.45	3.93	3.33	7.68	2.57	1.71	0.66	0.07	21.26
1878–79	.00	Tr.	.00	.14	Tr.	4.70	3.59	.97	.49	1.19	.24	.03	11.35
1879–80	.00	.00	.00	.93	3.44	6.53	1.33	1.56	1.45	5.06	.04	.00	20.34
1880–81	Tr.	Tr.	.00	.14	.67	8.40	1.43	.36	1.66	.46	.01	.00	13.13
1881–82	.00	Tr.	Tr.	.82	.27	.52	1.01	2.66	2.66	1.83	.63	Tr.	10.40
1882–83	.00	.00	Tr.	.05	1.82	.08	1.62	3.47	2.87	.15	2.02	.03	12.11
1883–84	Tr.	.00	.00	1.42	.00	2.56	3.15	13.37	12.36	3.54	.34	1.39	38.13
1884–85	Tr.	Tr.	Tr.	.30	1.06	4.64	1.05	Tr.	.01	2.00	.06	Tr.	9.12
1885–86	Tr.	Tr.	Tr.	.26	5.52	1.63	7.72	1.38	2.50	3.29	.00	.01	22.31
1886–87	.24	.21	.00	.01	1.18	.18	.20	9.25	.24	2.30	.20	.04	14.05
1887–88	.07	.00	.15	.12	.78	2.67	6.03	.77	3.15	.11	.02	Tr.	13.87
1888–89	.03	.08	Tr.	.36	4.01	6.26	.25	.92	6.48	.27	.62	.00	19.28
1889–90	.00	.61	.0	6.95	1.35	15.80	7.83	1.36	.66	.22	.03	.02	34.83
1890–91	.0	.03	.06	.03	.13	2.32	.25	8.56	.41	.26	.31	.00	12.36
1891–92	Tr.	.00	.06	.00	.00	1.99	.88	3.19	3.39	.22	2.06	.06	11.85
1892–93	.00	.01	.00	.33	4.40	4.18	6.29	2.27	8.52	.19	.06	.03	26.28
1893–94	.00	.00	Tr.	.75	.20	3.65	.94	.49	.37	.13	.20	Tr.	6.73
1894–95	Tr.	.01	.73	.02	.00	4.62	5.84	.46	3.77	.46	.19	.01	16.11
1895–96	Tr.	Tr.	Tr.	.24	.89	.78	3.23	Tr.	2.97	.19	.30	Tr.	8.51
1896–97	.02	.01	Tr.	1.30	1.63	2.12	3.70	5.62	2.31	.02	.10	Tr.	16.86
1897–98	Tr.	.00	.00	2.47	.01	.05	1.26	.51	.98	.03	1.75	Tr.	7.06
1898–99	.07	Tr.	.02	.09	Tr.	.12	2.64	.04	1.81	.18	.04	.58	5.59
1899–1900	.00	.01	Tr.	1.59	.93	.90	1.17	Tr.	.99	.54	1.81	Tr.	7.91
1900–1901	Tr.	Tr.	Tr.	.25	6.53	Tr.	2.49	4.38	.45	.68	1.50	Tr.	16.29
1901–2	Tr.	.09	.03	1.88	.46	Tr.	1.62	3.35	2.98	.16	.03	Tr.	10.60
1902–3	Tr	Tr	Tr.	.10	2.08	2.50	2.10	1.52	6.93	3.77	Tr.	.02	19.72
1903–4	.00	Tr.	.43	Tr	.00	Tr.	.14	2.68	4.50	.97	Tr.	Tr.	8.72

Average, twenty-seven years, 15.35 inches.

A close examination of the Anaheim profile shows that the decline was steady and uninterrupted during the three very dry years which preceded and included the winter of 1899–1900. The succeeding winter was one in which the rainfall at Anaheim, at Los Angeles, and at San Bernardino was somewhat in excess of the normal, the excess varying from 9 per cent at Los Angeles to 28 per cent at Anaheim.

During the early part of the winter of 1901 the Anaheim profile shows a sharp rise in the water level, the gain during the first three months of the year being approximately 2 feet, but by the middle of the succeeding August the water had fallen again to a lower level than it had reached at any time before this winter, whose rainfall exceeded the normal.

In short, the decline continued during a winter of excessive rainfall. Throughout the season of 1901–2 also it continued, but as this again was a winter of marked deficiency, a loss was to be expected.

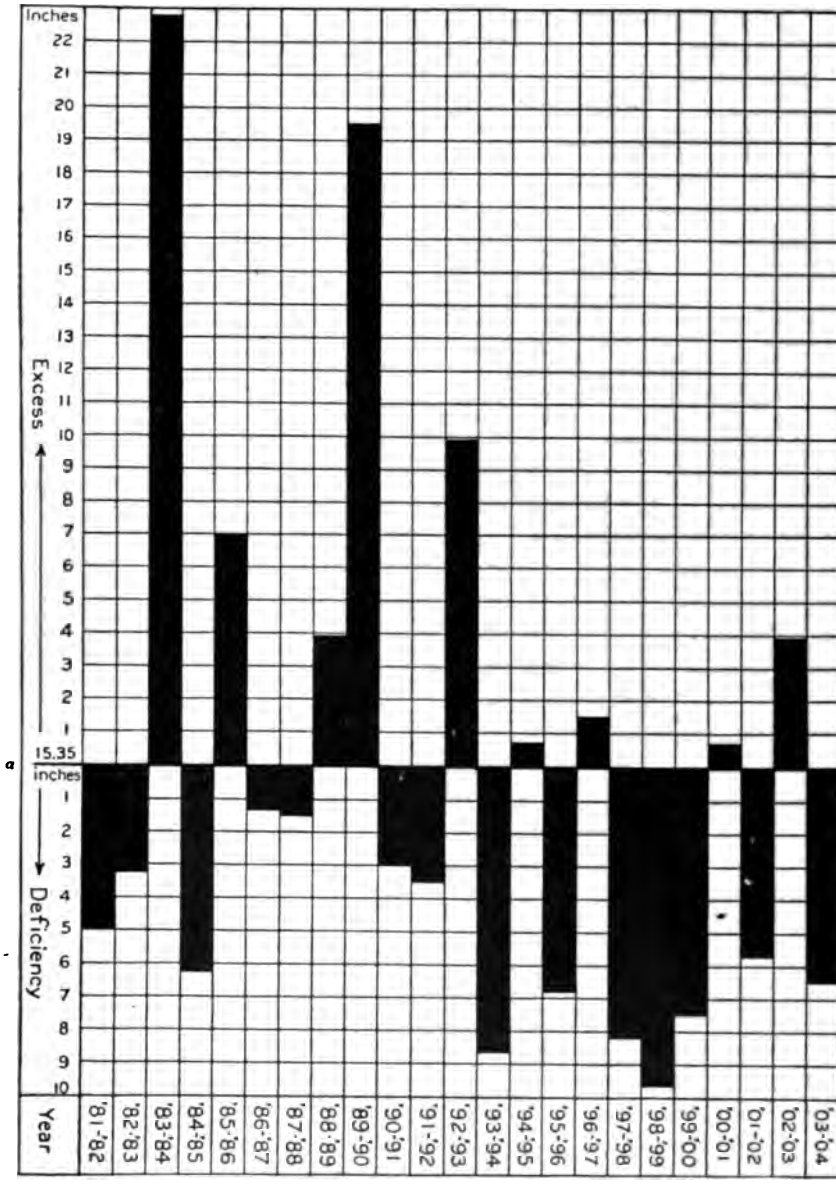

FIG. 3.—Chart showing departures from average rainfall at Los Angeles, Cal. *a*, average for 27 years (15.35 inches).

But the season of 1902–3 was again a winter of rainfall in excess. This excess amounted to about 15 per cent of the normal at San Bernardino, about 70 per cent at Anaheim, and about 22 per cent at

Los Angeles. The effect upon the Anaheim water level, while less marked than that of the heavy rainfall two years before, was more last ng, the rise of April and May, 1903, not being wholly lost until January 1, 1904. Since that time there has been no heavy rainfall and the decline has been continuous.

The important point in this comparison is the fact that the water level has continued to decline during two years of marked excess in precipitation. This fact seems to point unmistakably to excessive drafts upon the underground waters in the region to which it applies.

Direct observations of this kind have not been made in the Downey quadrangle, where there are only the general phenomena of decline

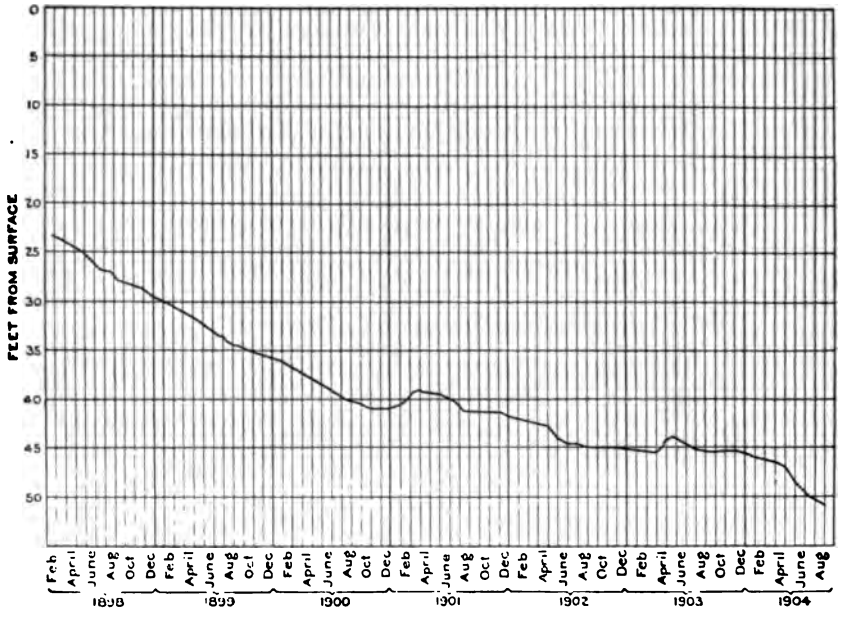

FIG. 1. Diagram showing variation of water level near Anaheim, Cal.

from which to draw conclusions. The artesian area exhibits as marked shrinkage in the Downey as in the Anaheim region, and it is known that ground-water levels have fallen there markedly. There are more artesian wells but fewer pumping plants. Since the yield of flowing wells is very sensitive to the fluctuations in the ground-water levels and to the accompanying changes in pressure, while the output of pumped wells responds much less freely to these variations, pumping may be considered the more efficient agent in reducing the supply. So as yet the conditions at Anaheim are thought to be extreme rather than general. The unlimited extension of developments, however, may soon result in their becoming general.

SUMMARY.

The discussion and conclusions as to the underground water supply in the central coastal plain region may be summarized thus:

(*a*) The supply is large, since it consists of the water saturating all of that part of the coastal plain gravels within pumping distance, say 250 feet from the surface, over an area of 600 or 700 square miles.

(*b*) The annual additions to the supply are large, consisting of a part of the flood waters of the San Gabriel, Los Angeles, and Santa Ana rivers, of the return waters from irrigation on the coastal plain, of the relatively small underflow of the rivers named, and of local rainfall upon this part of the coastal plain and the adjacent hills.

(*c*) The drafts upon these waters are large and seem certainly to be in excess of the supply in parts of the area at present.

(*d*) With present developments the water plane is expected to continue slowly to decline, and the artesian area to shrink until drainage is checked by these shrinkages at a point where it no longer exceeds supply. This decline should not prove serious *if present developments are not greatly increased.*

(*e*) So long as water developments continue at a rate which increases the output the shrinkage will continue.

(*f*) The lowering of the ground-water level and the shrinkage of artesian areas, even with continued development, will no doubt be interrupted by periods of rising water levels and expanding artesian areas, which will follow seasons of excessive rainfall.

(*g*) The shrinkage of the artesian belt will be most manifest along its northern edge. The effect farther south will be rather a decrease of flow and a lessening of pressure.

(*h*) Shallow artesian wells will generally be affected earlier and to a more marked extent than deeper ones.

DESCRIPTION OF MAPS AND TABLES.

The maps in this paper show the lands irrigated in 1903–4, the irrigation canals, all of which head in or near the Paso de Bartolo, the present and the original artesian basins, and the location of wells, artesian, pumped, or domestic, in the Downey and Las Bolsas quadrangles (Pls. I, II, and IV).

The irrigated lands and those not irrigated are less clearly differentiated in the naturally more or less moist lands of the lower parts of the coastal plain than on the dry mesa and bench lands, and irrigation practice is often vague and unsystematic there. In many cases winter irrigation is practiced, the waters of the San Gabriel reaching the lower stretches of the river channel or the lower ditches only at this season, when water is abundant. It is then used to augment the rainfall on pasture lands. Irrigation of this type is

included in our classification of irrigated lands. The total area under irrigation in the Downey and Las Bolsas quadrangles is nearly 45,000 acres, or about 25 per cent of the total area.

The map of the artesian basin, past and present (Pl. I), is self-explanatory. It is to be said, however, that the boundaries differ for wells of differing depth, since deep wells may flow when they are some distance farther north than shallower wells that have ceased to flow.

As the limits have been drawn on the maps they include within the artesian area all wells flowing at the time the data were collected in the summer of 1903 and the succeeding winter. After a very wet year the northern boundary of the present artesian area may shift to the north; with average rainfall and continued development it will probably shift to the south. The southern limit should show but little change.

Outside of the artesian basin the ground-water level has been shown by hydrographic contours (Pl. I). These are lines showing the elevation of the surface of the plane of saturation. The depth to ground water at any point is determined by finding the difference between the elevations indicated by the topographic contours and those indicated by the hydrographic contours. The line of hills which forms the southern limit of the artesian basin follows a zone in which the water levels are so irregular that it was not practicable to extend the hydrographic contours across it.

Three kinds of symbols are used to indicate wells that flow, wells at which pumping plants have been installed, and the small windmill and domestic wells. Thus the map shows approximately the artesian belt and the areas of greatest development by pumping. Both artesian wells and pumping plants are constantly increasing, and by the time this report is ready for distribution many more will exist than are shown on the map, although this list was nearly complete for artesian wells and pumping plants at the time the field work was finished, in the spring of 1904. Many of the small domestic wells have not been examined and do not appear in the lists. Each well visited has been located on the map and numbered there. The information collected concerning it appears in the tables opposite this number. The information includes the name of the owner, the rancho, or, if on public land surveys, the town, range, and section, the date of completion, the size and depth of the well, the depth of water and the elevation of its surface, the approximate amount of dissolved solids in parts per 100,000, the method used in raising the water, the approximate cost of the well and of the machinery installed, and the amount of water secured. The greater part of this information was obtained from the owner of the well, data as to cost being in all cases supplied by him. The

depths of shallower wells that were accessible were measured. If the well is more than 300 feet deep, or was capped or otherwise closed, the owner's statement was taken or the driller's record consulted.

In a great many cases it was necessary also to accept the owner's statement as to the output of his well. This was particularly true of the pumping plants. Artesian wells could much more often be measured, and in every case where it was possible determinations of output were made, whether the water was artesian or pumped. Owners' statements are usually excessive.

The purity of the water was rapidly and approximately determined in the field with an electrolytic bridge, the method being based upon the fact that a definite relation exists between the amount of dissolved solids in the waters and the electrical resistance. The degree of accuracy attained in this work is probably somewhat less for the Downey quadrangle than for the Las Bolsas quadrangle, which was examined at a cooler season, as high temperatures affect the accuracy of the method. It is hoped, however, that the tests are correct within five or six parts per 100,000 in nearly all cases and that their usual accuracy is much closer than this. The results are tabulated with the other data about the wells and have also been assembled on a map (fig. 5) on which the underground waters have been classified upon the basis of their alkalinity, and on which the distribution of the broader zones is shown. Such a map furnishes general evidence as to the course of the underground circulation, and in this case indicates that the waters which come out through the Paso de Bartolo spread into a broad stream, unite with those of the Los Angeles and Santa Ana systems, and seek an outlet to the ocean in the region between Los Alamito Beach and Newport Beach. The preparation of this map showed that shallow wells, even in the areas of generally pure water, often contain very notable amounts of alkalies and that the deeper wells generally carry a smaller proportion of salts than the shallower ones. The zones, as they have been mapped, represent the general condition of waters drawn from sufficient depth to be free from surface contamination. They illustrate well the effect of the run-off from the shale hills upon the waters in the adjacent lowlands, and show also the greater purity of the ground waters in the zones of freest underground circulation, as between the passes by which the greater streams reach the coastal plain and the seashore. They illustrate, too, the somewhat inferior quality of those ground waters which lie upon the seaward side of the ridge which limits the artesian basin on the southwest. These waters, it is to be said, are irregular in their alkalinity, near-by wells often exhibiting considerable differences in the quantity of dissolved salts. Within the lower parts of the

artesian basin, on the contrary, the waters are very uniform in quality and contain but little mineral matter.

The waters of several of the deep wells of the Downey quadrangle are more or less impregnated with sulphureted hydrogen, and some of them are stained brown, probably by vegetable matter, peaty in character, which has been buried as the sands and gravels have accumulated. The subterranean waters in contact with these peaty beds are colored just as surface waters in contact with vegetable matter in swamps or marshes become stained. These gaseous

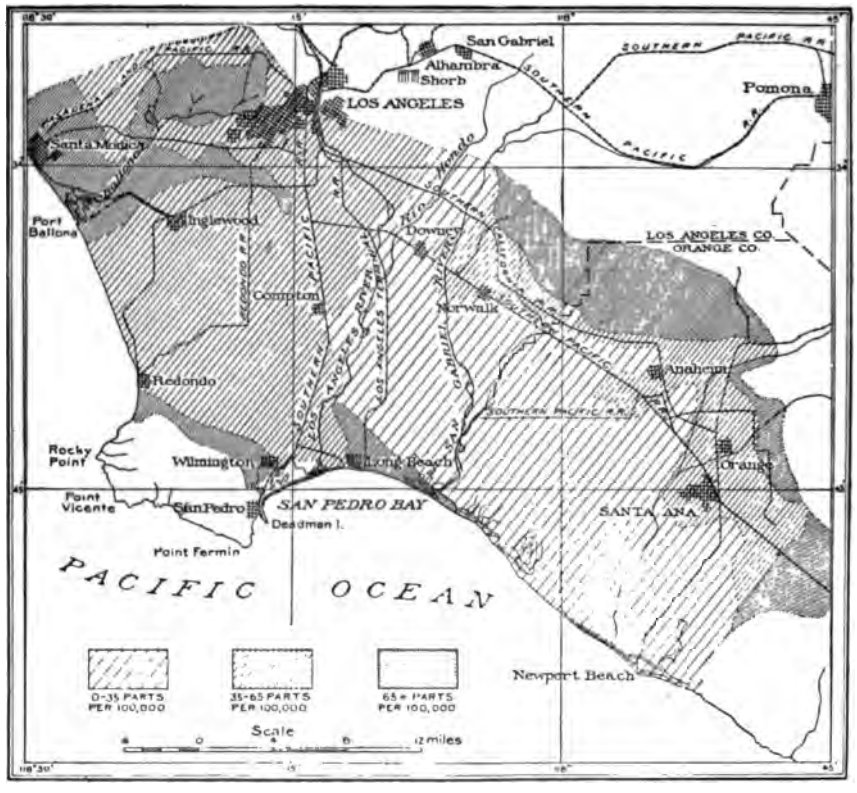

FIG. 5. Map showing approximate amounts of dissolved solids in underground waters of coastal plain region of southern California.

and organic elements affect the electrical resistance but little, if at all, and therefore do not appear in the tabulated and mapped results.

ACKNOWLEDGMENTS.

Much the greater part of the work of collecting the information in the field concerning wells and water levels on the Downey quadrangle was done by Messrs. A. C. Hansen and E. R. Furstenfeld, who also mapped the irrigated lands. Mr. W. N. White is chiefly responsible for the field work in the Las Bolsas quadrangle. The

task of tabulating the results of the field work and preparing maps and tables for publication has fallen principally upon Messrs. A. J. Fisk, jr., and W. N. White.

Acknowledgments are due also to the well owners and water companies who have responded to queries and have thereby enabled the data to be procured.

The work which has resulted in the collection of this material was originally planned and inaugurated by Messrs. J. B. Lippincott and Homer Hamlin, engineers of the Reclamation Service. The credit for its initiation is theirs exclusively, and except that the increasing pressure of the important work of the Reclamation Service has come to claim more and more of their energies this work would probably have been carried out to completion under their direction.

WELL DATA.

Wells in the Downey quadrangle.

[* Cost of well and equipment combined; † yield estimated or statement of owner taken; ? doubtful. The miner's inch used in these tables is the old California miner's inch, i. e., the amount of water which flows from a 1-inch orifice under a 4-inch head; it is equal to gallons per minute, 14,478 acre-feet per year or one-fiftieth second-foot.]

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1	J. H. Dutcher	San Antonio	A-1	1903	Bored, 10-inch	173	135	115	....	.....	$175.00	.....	Irrigation	.....
2	J. A. Gar	....do	A-2	1895	Bored, 7-inch	169	133	69	59	Wind	70.00	$175.00	Domestic	.....
3	F. Ahrens	....do	A-2	1898	Bored, 10-inch	176	132?	100	61	.....	140.00	.....	Irrigation	60
4	Z. S. Spaulding	....do	A-2	1898	....do	174	144?	100	....	Propeller pump.	150.00	1,250.00	....do	90
5	A. B. Merrill	....do	A-2	1889	Bored, 7-inch	174	133	55	....	Wind	65.00	75.00	Domestic; irrigation.	1½
6	C. Dutcher	....do	A-2	1897	....do	167	129?	100	....	Electric motor.	115.00	1,200.00	Irrigation	100
7	J. H. Dutcher	....do	A-2	1895	Bored, 8-inch	162	133	104	65	....do	175.00	1,200.00	....do	80
8	Chas. Gillon	....do	A-1	1900	Bored, 10-inch	175	135	87	....	Electricity	300.00	1,500.00	....do	135
9	Mrs. M. J. Russell	....do	A-2	1883	Bored, 7-inch	156	131	87	68	Hand	90.00	20.00	Domestic	.....
10	Geo. Logic	....do	A-3	1900	Bored, 3½-inch	150	128	93	69	....do	85.00	15.00	....do	.....
11	Mrs. Sarah Braby	....do	A-3	1883	Bored, 7-inch	148	128	93	....	Wind	.....	.....	....do	.....
12	Julius Conrad	....do	A-3	1896	Bored, 10-inch	146	129	480	30	Gas	600.00	1,000.00	Irrigation; domestic.	100
13	....do	....do	A-3	1896	Bored, 8-inch	146	129	140	56	....do	125.00	.....	....do	
14	Annette Thaxter	....do	A-3	1876	....do	142	128	111	54	Wind	150.00	175.00	Domestic	.....
15	Geo. Nadeau	....do	A-3	1883	Bored, 7-inch	144	124	180?	63	....do	180.00	135.00	....do	.....
17	D. W. Moore	....do	A-2	1902	....do	155	128?	115	61	....do	118.75	90.00	....do	.....
18	Quong Lung	Los Angeles city	A-1	1897?	Bored, 6-inch	185	138	54	....	....do	.....	.....	....do	.....
19	J. Inverarity	....do	A-1	1900	Bored, 7-inch	188	137	60	52	....do	65.00	200.00	....do	.....

20	A. Rueff	do	A-1	1898	do	89	137	54	62	do			do			
21	I. Gibbs	do	A-1	1902	Bored, 12-inch	193	138	90	57	Gas	157.50	2,200.00	Irrigation	120		
22	James Haddock	do	A-1	1891	Bored, 7-inch	193	139	60		Wind	65.00	200.00	Domestic	1		
23	Mrs. P. B. Hardenberg	do	A-1	1899?	do	195	140	65	52	do			do			
24	Pacific Electric Ry. Co.	do	A-1	1899	do	194	138	70		do			do			
25	Ida McClure	do	A-1	1882	do	192	137	61	46	do			do			
26	Chas. Hull	do	A-1	1881	do	191	122	77	48	do	85.00	75.00	do			
27	W. A. Ross	do	A-1	1902	do	183	135	68	38	do	56.00	152.00	do			
28	Burbank & Baker	San Antonio	A-2	1902	Bored, 10-inch	180	135	91	45	Gas			Irrigation; domestic.	50		
29	Estavan Herrera	do	A-2		Bored, 7-inch	179	134	75	43	Wind			Domestic	1		
30	John B. Morrison	do	A-2	1901	Bored, 10-inch	176	144?	97		Gas	140.00	1,375.00	Irrigation	142		
31	I. H. Bryson	do	A-2	1898	do	171	133	92	30	Electricity	200.00	1,050.00	do	75		
32	Wm. R. Roney	do	A-2	1901	do	164	128	415	49	do	1,500.00	1,500.00	do	52		
33	T. E. Cleland	do		1897	do	156	126?	260	42	do	500.00	1,200.00	do	†175		
34	R. A. Innes	do	A-2	1901	Bored, 7-inch	159	129	75	42	Wind	86.00	170.00	Domestic; irrigation.	1		
35	Michael Cudahy	do	B-2	1899	Bored, 12-inch	156	122	400?		Compressed air	1,000.00	2,000.00	Irrigation	60		
36	do	do	B-2	1900	do	155	121	400	34	do	1,000.00	2,000.00	do	60		
37	L. Wright	do	A, B-2	1887	do	169	133	85	51	Wind		164.00	Domestic	1½		
38	E. V. Baker	do	B-1	1902	Bored, 10-inch	181	135	277	39		456.00		Not used			
39	Dan Cunningham	do	B-2	1900	Bored, 12-inch	170	134	400	45	Compressed air	1,000.00		Irrigation	15		
40	Chas. Miles	do	B-2	1884	Bored, 7-inch	169?	132	85	42	Wind			Domestic			
41	Gail Borden	do	C-2	1884	do	153	126	91	40	do			do			
42	do	do	B-2	1900	Bored, 10-inch	158	128	121	37				Irrigation	60		
43	J. G. Bell	do	C-2	1899	Bored, 12-inch, 262 feet; 9½-inch, 374 feet.	158	133?	636	41	Propeller pump			Domestic; irrigation.	150		
44	E. G. Greening	do	C-½	1902	Dug, 3 by 3 foot	164	148	173	49	Hand	10.00	6.00	Domestic			
45	W. N. Angel	do	C-1	1894	Bored, 7-inch	177	142	112	44	Wind	125.00	100.00	Domestic; irrigation.	1½		
46	James Gillespie	do	B-1	1892	do	177	137	128	43	do	150.00	50.00	Domestic	1½		
47	G. W. Brookins	do	C-1	1900	Bored, 10-inch	179	148?	135		Propeller pump	200.00		Irrigation	95		
48	Fruitland Water Co	do	B-1	1898	Bored, 12-inch	177	126	250		Compressed air	1,000.00	1,700.00	do	50		
49	John H. Van Nest	do	C-1	1873	Bored, 7-inch	182	133	285	35	Wind		100.00	Domestic			
50	Steven Musante	do	C-1	1898	do	183	154	106	55	do	110.00	100.00	Domestic; irrigation.	1½		

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
51	J. S. Quinn	San Antonio	C-1	1901	Bored, 9-inch	180	140	100	39	Wind	$300.00		Domestic	1½
52	A. E. Bell	San Pedro	D-2	1898	Bored, 10-inch	148	136	1,360	39	Electricity	1,500.00	$1,200.00	Irrigation	150
53	F. F. Culver	do	B-8	1873?	Bored, 6-inch	73	73	230		Artesian	400.00		Domestic	
54	Frank Walton	do	A, B-8	1902	Bored, 10-inch	73	73	500	32	do	700.00		Irrigation	1
55	A. C. Bird	do	A-8	1885	Bored, 7-inch	82	82	170	33	Wind, artesian	150.00	350.00	Domestic	1½
56	Mrs. Minnie Stuart	do	A-8	1891	do	84	81	160		Gas		400.00	Irrigation	30
57	Mrs. H. C. Montague	do	A-8	1894	do	81	81	192		Artesian	500.00		Not used	
58	Chas. Marble	do	A-8	1898	do	89		300		Gas	600.00	450.00	Irrigation	40
59	C. A. Conklin	do	A-7	1896	do	88		200		do	400.00	600.00	do	40
60	Mrs. A. C. Brown	do	A-8	1902	Dug, 3½ by 3½ foot.	89	70	20	115	Hand	20.00	3.50	Stock	
61	J. E. Paradis	do	A-8	1881?	Bored, 7-inch	94	81	198		Gas	300.00	1,000.00	Irrigation	75
62	W. D. Suly	do	A-7	1892	Bored, 6-inch?	90	82	200		Wind	150.00	30.00	Domestic	1½
63	F. M. Elliott	San Antonio	A-7	1895?	Bored, 7-inch	84	84	200	33	Gas, artesian		900.00	Domestic; irrigation.	30
64	Francis E. Barron	San Pedro	A-7	1898	do	79	79	260	40	Artesian	400.00		do	
65	H. P. Schildwachter	San Antonio	A-7	1883	do	82	82	140		Wind, artesian		145.00	Domestic	
66	F. L. Walton	do	A-7	1895	Hydraulic, 2-inch.	84	84	223	43	do	100.00	140.00	do	Small.
67	do	do	A-6, 7	1895	do	87	87	228		do	180.00	150.00	do	
68	J. E. Lodge	do	A-6	1897	Bored, 7-inch	88	88	200	44	Gas, artesian	350.00	600.00	Irrigation; domestic.	75
69	E. S. Gunby	do	A-6	1888	do	91	91	240		do	500.00	750.00	do	85
70	I. E. Herson	do	A-6	1900	do	91	91	250		do	350.00	700.00	do	60
71	Geo. Wittman	do	A-5		do	96	91		43	Artesian			Domestic	†5
72	G. H. Bollinger	do	A-5, 6	1883	do	98	98	240	42	do	600.00		do	†1

73	J. G. Belleu	do	A-5	1889	do	100	100	70	55	do	100.00	Domestic; irrigation.	
74	Miss Hersey	do	A-5	1891	Bored, 10-inch	102	102	80		do		Irrigation	1
75	Z. A. Towne	do	A-4,5	1897	Bored, 7-inch	112	112	77	56	do	77.00	Domestic; irrigation.	15
76	Mrs. L. Diller	do	A-5	1882	do	112	112	87	61	do		Domestic	Small.
77	Mrs. F. E. Rausaur	do	A-4	1881	Bored, 10-inch	117	117	72	51	Wind, artesian	90.00	200.00	do
78	David Elcoat	do	A-4	1896	Bored, 7-inch	123	123	87	55	do	100.00	50.00	do
79	H. D. Merrill	do	A-4	1883	do	130	124	120	66	Gas	125.00	350.00	Irrigation	50
80	A. E. Putney	do	A-3	1892	do	135	126	137	66	Compressed air	225.00	1,000.00	do	70
81	J. N. Stone	do	A-3	1873	do	134	127	122	61	Gas	180.00	550.00	Irrigation; domestic.	50
82	Hugh Glassell	do	A-3	1872	Bored, 12-inch	144	126			do			Irrigation	75
83	A. D. Westbrook	do	A-3		Bored, 7-inch	144	127	112	53	Wind			Domestic	
84	Mrs. Jennie E. Fall	do	A-3	1902	do	151	127	67	71	do	85.00	50.00	do	1
85	Michael Cudahy	do	B-3	1889	do	144	131	35	47	do		125.00	do	
86	do	do	B-3	1890	do	137	134	140		do	90.00	75.00	do	
87	E. Northcote	do	A-3		do	133	124	120		do			do	
88	Mr. Slauson	do	B-3	1882?	do	134	126	133	49	Hand			do	
89	H. T. Starks	do	A-4	1900	Bored, 10-inch	122	121	132	37	Gas	400.00	800.00	Irrigation	100
90	Jacob Bosshard	do	A-4	1898	Bored, 7-inch	126	122	85	63	Wind	102.00	200.00	Domestic	1
91	Mrs. Mary Tweedy	do	B-4	1887	Bored, 4-inch	126	123	113	57	do			do	1
92	F. H. Robinson	do	B-4	1885	Bored, 7-inch	109	108	106	52	do		100.00	do	1
93	Mrs. H. C. Carson	San Pedro	B-7	1875	Bored, 2-inch	75	75	259	32	Artesian			do	
94	P. J. Boland	do	B-7	1890	Bored, 4-inch	76	76	135	37	do			do	
95	L. F. Stockwell	San Antonio	B-6,7	1898	Bored, 3-inch	75	75	241		do	100.00		Domestic; irrigation.	10
96	Mr. F. Walton	San Pedro	B-7		Bored, 7-inch	74	74	250	31	do			Irrigation; stock	
97	D. W. Imbler	do	A-7	1902	do	80	80	257	36	do	355.00		Irrigation	50
98	S. J. Hull	do	A-7	1900	do	78	78	247	33	do	500.00		do	75
99	J. Schaefer	do	B-7	1888	do	73	73	320	36	do	500.00		Irrigation; domestic.	
100	S. Stockwell	do	C-7	1885	do	81	81	144	41	do	700.00		do	20
101	G. F. Howe	do	D, E-8	1900	do	65	65	167	30	Hand			Domestic	
102	J. B. Proctor	do	D-8		Bored, 4-inch	70	70	145	29	Hand, artesian			do	
103	C. Wright	do	D-8		Bored, 8-inch	72	72		29	Artesian			do	
104	Los Angeles County	do	D-8	1900	Hydraulic, 3-inch.	73	73	208	36	do	150.00		Roads	

WELL DATA.

Wells in the Downey quadrangle.

[* Cost of well and equipment combined; † yield estimated or statement of owner taken; ? doubtful. The miner's inch used in these tables is the old California miner's inch, i. e., the amount of water which flows from a 1-inch orifice under a 4-inch head; it is equal to 9 gallons per minute, 14,478 acre-feet per year or one-fiftieth second-foot.]

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1	J. H. Dutcher	San Antonio	A-1	1903	Bored, 10-inch	173	135	115			$175.00		Irrigation	
2	J. A. Gar	do	A-2	1895	Bored, 7-inch	169	133	69	59	Wind	70.00	$175.00	Domestic	
3	F. Ahrens	do	A-2	1898	Bored, 10-inch	176	132?	100	61		140.00		Irrigation	60
4	Z. S. Spaulding	do	A-2	1898	do	174	144?	100		Propeller pump.	150.00	1,250.00	do	90
5	A. B. Merrill	do	A-2	1889	Bored, 7-inch	174	133	55		Wind	65.00	75.00	Domestic; irrigation.	1½
6	C. Dutcher	do	A-2	1897	do	167	129?	100		Electric motor.	115.00	1,200.00	Irrigation	100
7	J. H. Dutcher	do	A-2	1895	Bored, 8-inch	162	133	104	65	do	175.00	1,200.00	do	80
8	Chas. Gillon	do	A-1	1900	Bored, 10-inch	175	135	87		Electricity	300.00	1,500.00	do	135
9	Mrs. M. J. Russell	do	A-2	1883	Bored, 7-inch	156	131	87	68	Hand	90.00	20.00	Domestic	
10	Geo. Logic	do	A-3	1900	Bored, 3½-inch	150	128	93	69	do	85.00	15.00	do	
11	Mrs. Sarah Braby	do	A-3	1883	Bored, 7-inch	148	128	93		Wind			do	
12	Julius Conrad	do	A-3	1896	Bored, 10-inch	146	120	480	30	Gas	600.00	1,000.00	Irrigation; domestic.	100
13	do	do	A-3	1896	Bored, 8-inch	146	129	140	56	do	125.00		do	
14	Annette Thaxter	do	A-3	1876	do	142	128	111	54	Wind	150.00	175.00	Domestic	
15	Geo. Nadeau	do	A-3	1883	Bored, 7-inch	144	124	180?	63	do	180.00	135.00	do	
17	D. W. Moore	do	A-2	1902	do	155	128?	115	61	do	118.75	90.00	do	
18	Quong Lung	Los Angeles city	A-1	1897?	Bored, 6-inch	185	138	54		do			do	
19	J. Inverarity	do	A-1	1900	Bored, 7-inch	188	137	60	52	do	65.00	200.00	do	

20	A. Rueff	do	A-1	1898	do	89	137	54	62	do			do	
21	I. Gibbs	do	A-1	1902	Bored, 12-inch	193	138	90	57	Gas	157.50	2,200.00	Irrigation	120
22	James Haddock	do	A-1	1891	Bored, 7-inch	193	139	60		Wind	65.00	200.00	Domestic	1
23	Mrs. P. B. Hardenberg	do	A-1	1899?	do	195	140	65	52	do			do	
24	Pacific Electric Ry. Co.	do	A-1	1899	do	194	138	70		do			do	
25	Ida McClure	do	A-1	1882	do	192	137	61	46	do			do	
26	Chas. Hull	do	A-1	1881	do	191	122	77	48	do	85.00	75.00	do	
27	W. A. Ross	do	A-1	1902	do	183	135	68	38	do	56.00	152.00	do	
28	Burbank & Baker	San Antonio	A-2	1902	Bored, 10-inch	180	135	91	45	Gas			Irrigation; domestic.	50
29	Estavan Herrera	do	A-2		Bored, 7-inch	179	134	75	43	Wind			Domestic	1
30	John B. Morrison	do	A-2	1901	Bored, 10-inch	176	144?	97		Gas	140.00	1,375.00	Irrigation	142
31	I. H. Bryson	do	A-2	1898	do	171	133	92	30	Electricity	200.00	1,050.00	do	75
32	Wm. R. Roney	do	A-2	1901	do	164	128	415	49	do	1,500.00	1,500.00	do	52
33	T. E. Cleland	do		1897	do	156	126?	260	42	do	500.00	1,200.00	do	†175
34	R. A. Innes	do	A-2	1901	Bored, 7-inch	159	129	75	42	Wind	86.00	170.00	Domestic; irrigation.	1
35	Michael Cudahy	do	B-2	1899	Bored, 12-inch	156	122	400?		Compressed air	1,000.00	2,000.00	Irrigation	60
36	do	do	B-2	1900	do	155	121	400	34	do	1,000.00	2,000.00	do	60
37	L. Wright	do	A, B-2	1887	do	169	133	85	51	Wind		164.00	Domestic	1½
38	E. V. Baker	do	B-1	1902	Bored, 10-inch	181	135	277	39		456.00		Not used	
39	Dan Cunningham	do	B-2	1900	Bored, 12-inch	170	134	400	45	Compressed air	1,000.00		Irrigation	15
40	Chas. Miles	do	B-2	1884	Bored, 7-inch	169?	132	85	42	Wind			Domestic	
41	Gail Borden	do	C-2	1884	do	153	126	91	40	do			do	
42	do	do	B-2	1900	Bored, 10-inch	158	128	121	37				Irrigation	60
43	J. G. Bell	do	C-2	1899	Bored, 12-inch, 262 feet; 9½-inch, 374 feet.	158	133?	636	41	Propeller pump			Domestic; irrigation.	150
44	E. G. Greening	do	C-½	1902	Dug, 3 by 3 foot	164	148	173	49	Hand	10.00	6.00	Domestic	
45	W. N. Angel	do	C-1	1894	Bored, 7-inch	177	142	112	44	Wind	125.00	100.00	Domestic; irrigation.	1½
46	James Gillespie	do	B-1	1892	do	177	137	128	43	do	150.00	50.00	Domestic	1½
47	G. W. Brookins	do	C-1	1900	Bored, 10-inch	179	148?	135		Propeller pump	200.00		Irrigation	95
48	Fruitland Water Co	do	B-1	1898	Bored, 12-inch	177	126	250		Compressed air	1,000.00	1,700.00	do	50
49	John H. Van Nest	do	C-1	1873	Bored, 7-inch	182	133	285	35	Wind		100.00	Domestic	
50	Steven Musante	do	C-1	1898	do	183	154	106	55	do	110.00	100.00	Domestic; irrigation.	1½

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
51	J. S. Quinn	San Antonio	C-1	1901	Bored, 9-inch	180	140	100	39	Wind	$300.00		Domestic	1½
52	A. E. Bell	San Pedro	D-2	1898	Bored, 10-inch	148	136	1,360	39	Electricity	1,500.00	$1,200.00	Irrigation	150
53	F. F. Culver	....do	B-8	1873?	Bored, 6-inch	73	73	230	....	Artesian	400.00		Domestic	.....
54	Frank Walton	....do	A, B-8	1902	Bored, 10-inch	73	73	500	32	....do	700.00		Irrigation	1
55	A. C. Bird	....do	A-8	1885	Bored, 7-inch	82	82	170	33	Wind, artesian	150.00	350.00	Domestic	1½
56	Mrs. Minnie Stuart	....do	A-8	1891	....do	84	81	160	....	Gas		400.00	Irrigation	30
57	Mrs. H. C. Montague	....do	A-8	1894	....do	81	81	192	....	Artesian	500.00		Not used	.....
58	Chas. Marble	....do	A-8	1898	....do	89	.....	300	....	Gas	600.00	450.00	Irrigation	40
59	C. A. Conklin	....do	A-7	1896	....do	88	.....	200	....	....do	400.00	600.00	....do	40
60	Mrs. A. C. Brown	....do	A-8	1902	Dug, 3½ by 3½ foot.	89	70	20	115	Hand	20.00	3.50	Stock	.....
61	J. E. Paradis	....do	A-8	1881?	Bored, 7-inch	94	81	198	....	Gas	300.00	1,000.00	Irrigation	75
62	W. D. Suly	....do	A-7	1892	Bored, 6-inch?	90	82	200	....	Wind	150.00	30.00	Domestic	1½
63	F. M. Elliott	San Antonio	A-7	1895?	Bored, 7-inch	84	84	200	33	Gas, artesian		900.00	Domestic; irrigation.	30
64	Francis E. Barron	San Pedro	A-7	1898	....do	79	79	260	40	Artesian	400.00		....do	.....
65	H. P. Schildwachter	San Antonio	A-7	1883	....do	82	82	140	....	Wind, artesian		145.00	Domestic	.....
66	F. L. Walton	....do	A-7	1895	Hydraulic, 2-inch.	84	84	223	43	....do	100.00	140.00	....do	Small.
67	....do	....do	A-6,7	1895	....do	87	87	228	....	....do	180.00	150.00	....do	.....
68	J. E. Lodge	....do	A-6	1897	Bored, 7-inch	88	88	200	44	Gas, artesian	350.00	600.00	Irrigation; domestic.	75
69	E. S. Gunby	....do	A-6	1888	....do	91	91	240	....	....do	500.00	750.00	....do	85
70	I. E. Herson	....do	A-6	1900	....do	91	91	250	....	....do	350.00	700.00	....do	60
71	Geo. Wittman	....do	A-5	.....	....do	96	91	.....	43	Artesian			Domestic	†5
72	G. H. Bollinger	....do	A-5,6	1883	....do	98	98	240	42	....do	600.00		....do	†1

73	J. G. Belieu	do	A-5	1899	do	100	100	70	55	do	100.00		Domestic; irrigation.	
74	Miss Hersey	do	A-5	1891	Bored, 10-inch	102	102	80		do			Irrigation	1
75	Z. A. Towne	do	A-4,5	1897	Bored, 7-inch	112	112	77	56	do	77.00		Domestic; irrigation.	15
76	Mrs. L. Diller	do	A-5	1882	do	112	112	87	61	do			Domestic	Small.
77	Mrs. F. E. Rausaur	do	A-4	1881	Bored, 10-inch	117	117	72	51	Wind, artesian	90.00	200.00	do	
78	David Elcoat	do	A-4	1896	Bored, 7-inch	123	123	87	55	do	100.00	50.00	do	
79	H. D. Merrill	do	A-4	1883	do	130	124	120	66	Gas	125.00	350.00	Irrigation	50
80	A. E. Putney	do	A-3	1892	do	135	126	137	66	Compressed air	225.00	1,000.00	do	70
81	J. N. Stone	do	A-3	1873	do	134	127	122	61	Gas	180.00	550.00	Irrigation; domestic.	50
82	Hugh Glassell	do	A-3	1872	Bored, 12-inch	144	126			do			Irrigation	75
83	A. D. Westbrook	do	A-3		Bored, 7-inch	144	127	112	53	Wind			Domestic	
84	Mrs. Jennie E. Fall	do	A-3	1902	do	151	127	67	71	do	85.00	50.00	do	1
85	Michael Cudahy	do	B-3	1889	do	144	131	35	47	do		125.00	do	
86	do	do	B-3	1890	do	137	134	140		do	90.00	75.00	do	
87	E. Northcote	do	A-3		do	133	124	120		do			do	
88	Mr. Slauson	do	B-3	1882?	do	134	126	133	49	Hand			do	
89	H. T. Starks	do	A-4	1900	Bored, 10-inch	122	121	132	37	Gas	400.00	800.00	Irrigation	100
90	Jacob Bosshard	do	A-4	1898	Bored, 7-inch	128	122	85	63	Wind	102.00	200.00	Domestic	1
91	Mrs. Mary Tweedy	do	B-4	1887	Bored, 4-inch	126	123	113	57	do			do	1
92	F. H. Robinson	do	B-4	1885	Bored, 7-inch	109	108	106	52	do		100.00	do	1
93	Mrs. H. C. Carson	San Pedro	B-7	1875	Bored, 2-inch	75	75	259	32	Artesian			do	
94	P. J. Boland	do	B-7	1890	Bored, 4-inch	76	76	135	37	do			do	
95	L. F. Stockwell	San Antonio	B-6,7	1898	Bored, 3-inch	75	75	241		do	100.00		Domestic; irrigation.	10
96	Mr. F. Walton	San Pedro	B-7		Bored, 7-inch	74	74	250	31	do			Irrigation; stock	
97	D. W. Imbler	do	A-7	1902	do	80	80	257	36	do	355.00		Irrigation	50
98	S. J. Hull	do	A-7	1900	do	78	78	247	33	do	500.00		do	75
99	J. Schaefer	do	B-7	1888	do	73	73	320	36	do	500.00		Irrigation; domestic.	
100	S. Stockwell	do	C-7	1885	do	81	81	144	41	do	700.00		do	20
101	G. F. Howe	do	D, E-8	1900	do	65	65	167	30	Hand			Domestic	
102	J. B. Proctor	do	D-8		Bored, 4-inch	70	70	145	29	Hand, artesian			do	
103	C. Wright	do	D-8		Bored, 8-inch	72	72		29	Artesian			do	
104	Los Angeles County	do	D-8	1900	Hydraulic, 3-inch	73	73	208	36	do	150.00		Roads	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
105	E. M. James	San Pedro	C-8	1902	Driven, 2½-inch	71	71	117	35	Wind	$75.00	$125.00	Domestic	
106	A. J. Morrison & Co	do	C-7	1893	Bored, 8½-inch	74	74	388	32	Artesian	1,000.00		Irrigation	†50
107	do	do	C-8	1902	Bored, 7-inch	69	69	130	44	Gas, artesian	175.00	800.00	do	†110
108	L. A. Leavitt	do	C-8	1895	Bored, 4-inch	67	67	250	36	Artesian	250.00		Domestic	
109	R. H. Dinsmore	do	C-8	1901	Bored, 3-inch	69	69	268	36	do	225.00		do	5
110	T. F. Shields	do	C-8	1896	Bored, 2-inch	72	72	133	41	Gas, artesian	175.00	300.00	Irrigation; domestic.	Small.
111	F. Colten	do	C-8	1880	Bored, 7-inch	72	72	140	41	Wind, artesian	250.00	150.00	Domestic	
112	J. W. Duff	do	C-7	1897	Hydraulic, 2-inch	80	80	305	39	Artesian	200.00		do	
113	M. L. McIntosh	do	C-7	1877	Bored, 7-inch	78	78	330	38	do	500.00		do	7
114	Mrs. S. Kriem	do	C-7	1896	do	71	71	535	29	do	500.00			25
115	R. B. Easley	do	C-7	1902	Bored, 10-inch	79	79	150	36	Gas, artesian	250.00	800.00	Irrigation	†100
116	H. Williams	do	C-7	1898	Bored, 12-inch	82	82	425	35	Artesian	800.00		do	†80
117	G. Palmer	do	C-7	1896	Bored, 7-inch	76	76	135	40	do	150.00		Domestic; irrigation.	
118	F. Vennass	do	B-7	1875	Bored, 5-inch	75	75	145	40	do	150.00		Domestic; stock	
119	L. Abbott	do	B-7	1896	Bored, 7-inch	78	78	145	39	do	150.00		Irrigation; domestic.	
120	H. C. Carson	do		1873	do	73	73	264	31	do			Domestic; irrigation.	
121	F. E. Stockwell	San Antonio	C-7	1893	do	83	83	148	33	do	150.00		Irrigation; domestic.	
122	E. H. Kincaid	do	C-7	1900	Bored, 9-inch	86	86	220	30	do	600.00		do	8
123	C. J. Williams & Co	do	C-6	1899	Bored, 10-inch	86	86	385	26	do	1,200.00		Irrigation	30
124	J. Gapper	do	C-6	1895	Bored, 7-inch	86	86	146	31	Wind, artesian	150.00	145.00	Domestic	

125	J. O. Waite	do	D-7	1900	Bored, 9½-inch	83	83	475	30	Artesian	900.00		Irrigation	75
126	S. S. Mills	do	D-7	1897	Bored, 7-inch	84	84	170	36	Wind, artesian		70.00	Domestic	
127	P. E. Hoag	do	D-7	1885	do	88	88	150	32	Wind			do	
128	W. W. Young	do	D-6	1902	Bored, 10-inch	86	86	176	38	Gas, artesian	319.65	1,000.00	Irrigation; domestic	
129	W. C. Lee	San Pedro	D-7	1898	Bored, 7-inch	77	77	150	37	Artesian	200.00		Domestic	15
130	do	do	D-7	1900	Bored, 10-inch	78	78	390	30	do	800.00		Irrigation	75
131	C. Venza	do	D-7	1896	Bored, 7-inch	79	79	136	35	Wind, hand			Domestic	
132	W. E. Boster	do	D-7	1880	do	81	81	283	36	Hand	550.00	10.00	do	
133	Mrs. McCarty	San Antonio	D 7	1895	Bored, 3-inch	60	60	180	37	Hand, artesian			do	
134	T. H. Abbott	do	D-6	1889	Bored, 7-inch	89	89	165	34	Wind, artesian	250.00	160.00	do	Small.
135	B. T. Rozelle	do	E 6	1880	do	89	89	130	35	do	300.00	100.00	do	Small.
136	do	do	D-6	1896	Bored, 10-inch	89	89	762	19	Gas, artesian	2,500.00	1,400.00	Irrigation	75
137	C. H. Watts	do	D-6	1899	do	91	91	800	22	Artesian	2,800.00		do	†85
138	W. B. Finch	do	C-6	1895	Bored, 7-inch	89	89	360	35	do			Irrigation; domestic	75
139	Elmer E. Moore	do	C-6	1895	Bored, 10-inch	95	95	467	25	do	1,150.00		Irrigation	†75
140	do	do	C-6		Bored, 7-inch	98	98	150	26	Gas, artesian	700.00	500.00	do	75
141	do	do	C-6		do	93	93	150	36	Wind, artesian	150.00	143.00	Domestic	Small.
142	A. W. Andrews	do	C-6	1895	do	92	92	180	35	do		35.00	Domestic; irrigation	
143	Mr. Carres	do	D-6	1903	Bored, 12-inch	91	91	652	33	Artesian	1,500.00		Irrigation	100
144	E. W. Lewis	do	C-6	1899	do	92	92	385	36	do	1,000.00		do	200
145	C. H. Sessions	do	B-7		Bored, 7-inch	82	82	140?	37	Hand, artesian		10.00	Domestic	2
146	do	do	C-5	1898	Bored, 12-inch	97	97	375	37	Artesian	600.00		Stock irrigation	†100
147	L. Snodgrass	do	B-5	1883?	Bored, 7-inch	96	96	80	46	do	150.00		Domestic	15
148	do	do	B-5	1883?	do	106	106	80	44	do	150.00		Stock irrigation	
149	Omri Bullis	do	B-5	1901	do	92	92	80?	39	do	100.00		Irrigation	20
150	do	do	B-6	1890?	do	92	92	335	31	Hand, artesian	1,000.00		Irrigation; domestic	
151	F. Hoppe	do	B-5	1903	Bored, 10-inch	99	99	385	37	Artesian	1,000.00		Irrigation	30
152	J. Tweedy	do	B-5	1893	Bored, 4-inch	111	111	72	48	Hand, artesian	75.00	10.00	Domestic	
153	Mr. Gilky	do	C-5	1880	Bored, 8-inch	101	101	135	37	Artesian	300.00		Domestic; irrigation	30
154	J. Abola	do	B-5		Bored, 7-inch	102	102	135?	45	do			Stock; irrigation	15
155	B. R. Kratzer	do	C-5	1890?	do	102	102	160	36	Wind, artesian	300.00	50.00	Domestic	
156	K. Swantek	do	C-5	1903	Bored, 10-inch	104	104	156	35		250.00		Not used	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
157	Mrs. E. Bryson	San Antonio	C-5	1900	Bored, 2-inch	105	.....	130?	36	Wind	$70.00?	$40.00	Domestic	.....
158	J. N. Sherman	do	C-5	1897?	do	106	106	120?	37	Wind, artesian	.....	128.20	do	.....
159	D. B. Dodson	do	D-5	1902	Bored, 7-inch	106	101	142	37	Wind	188.00	100.00	Domestic; stock; irrigation.	.....
160	H. P King	do	D-5	.....	do	105	96	140	33	Hand	.....	.....	Domestic	.....
161	M. T. King	do	D-5	1899	Hydraulic, 2-inch.	105	102	110	30	Wind	41.40	108.00	Stock; domestic	.....
162	J. M. Shaw	do	D-5	1899	Bored, 4-inch	103	95	155	31	Hand	175.00	.....	Domestic	.....
163	R. Wallace	do	D-5	1898?	Bored, 10-inch	100	100	600+	29	Artesian	.....	.....	Irrigation	60
164	W. H. Corbin	San Pedro	B-8	.....	Bored, 4-inch	62	62	425?	33	do	.....	.....	Domestic	.....
165	W. A. Hall	do	B 8	1901	Bored, 6-inch	62	62	263	36	do	400.00	.....	Irrigation	11
166	James Davidson	do	B-8	.....	Driven, 2-inch	62	62	.....	33	do	.....	.....	Domestic; stock	.....
167	Dr. J. A. Monk	do	B-8	1900	Bored, 12-inch	50	59	811	30	do	3,000.00	.....	Irrigation	90
168	L. Gully	do	B-8	1899?	Bored, 10-inch	63	63	460	35	do	.....	.....	do	62
169	W. S. Peck	do	C-8	1894	Bored, 8-inch	63	63	320	35	do	400.00	.....	do	.....
170	W. L. Peck	do	C-8	1897	Bored, 3-inch	60	60	300	34	do	.....	.....	Domestic; irrigation.	.....
171	J.. G. Hawthorn & Son	do	C-8	1873?	Bored, 7-inch	60	60	237	38	Wind, artesian	500.00	.....	Domestic	Small.
172	do	do	C-8	1900	Bored, 10-inch	62	.....	130	....	Gas	200.00	800.00	Irrigation	100
173	James Legg	do	C-8	1891	Bored, 7-inch	69	69	130	35	Wind, artesian	200.00	120.00	Domestic; irrigation.	.....
174	H. B. Rice	do	C-8	1899	Bored, 10-inch	62	55	132	30	Gas	200.00	1,000.00	Irrigation	90
175	F. K. Day	do	C-8	1902	Bored, 7-inch	65	61	130	38	do	95.00	520.00	do	50
176	D. R. Meyers	do	D-8	1878?	do	69	.....	500	....	do	1,600.00	550.00	do	70
177	R. B. Harris	do	C-8	1899	Bored, 9½-inch	63	63	400	36	Artesian	600.00	.....	do	†35

178	.....do.....	.....do.....	C-8.....	1883	Bored, 7-inch.....	63	.....	400	.....	Gas.....	.....	700.00	.....do.....	†95
179	John Gains.....	.....do.....	D-8.....	.....	Bored, 8-inch.....	69	69	400	35	Hand.....	.....	.....	Domestic.....	.....
180	H. W. Marden.....	.....do.....	E-8.....	1901	Hydraulic, 2-inch.	63	63	457	33	Artesian.....	202.00	.....	.....do.....	.....
181	.....do.....	Los Cerritos.....	E-8.....	1903?	Bored, 10-inch....	65	65	111	33	.....	188.77	.....	Not used.....	.....
182	Wm. Sneary.....	.....do.....	E-8.....	.....	Bored, 2-inch....	67	67	540	29	Artesian.....	.....	.....	Domestic; irrigation.	.....
183	T. J. Luccock.....	.....do.....	E 8.....	1891	Bored, 4-inch.....	68	65	150	30	Hand.....	150.00	.....	Domestic.....	.....
184	Mrs. Swanson.....	.....do.....	E 8.....	1902	Hydraulic, 2-inch.	68	68	550	28	Artesian.....	150.00	.....	.....do.....	†3
185	H. A. Daris.....	.....do.....	E 9.....	1899	.....do.....	63	63	576	28	.....do.....	175.00	.....	.....do.....	Small.
186	J. S. Mansfield.....	.....do.....	E-8.....	1899	.....do.....	64	64	600	.....	.....do.....	200.00	.....	Domestic; irrigation.	†5
187	T. H. Samers.....	.....do.....	E-9.....	1899	Bored, 3-inch.....	60	60	100	34	.....do.....	60.00	.....	Domestic.....	Small.
188	R. H. Parker.....	.....do.....	E-9.....	1899	Hydraulic, 2-inch.	61	61	376	32	.....do.....	150.00	.....	Irrigation.....	.....
189	A. E. Matson.....	.....do.....	E-9.....	1899	Driven, 3-inch....	60	60	100	30	.....do.....	75.00	.....	Domestic; irrigation.	.....
190	G. W. Calionette.....	.....do.....	E-9.....	1899	Bored, 6-inch.....	61	61	160	31	.....do.....	150.00	.....	Domestic; stock.	Small.
191	F. E. Green.....	.....do.....	E-10....	1901	Hydraulic, 2-inch.	56	56	398	33	.....do.....	160.00	.....	Irrigation.....	.....
192	J. E. Cook.....	.....do.....	E-10....	1900	.....do.....	58	58	430	....	.....do.....	.....	.....	Stock.....	.....
193	Robert Syrett.....	.....do.....	E-10....	1898	Bored, 2-inch.....	54	54	356	30	.....do.....	106.50	.....	Domestic; stock.	1
194	W. S. McKenzie.....	.....do.....	D-10....	1898	Bored, 8-inch.....	53	53	350	32	.....do.....	.....	.....	Irrigation.....	.....
195	W. H. Brown.....	.....do.....	E-10....	1897	Hydraulic, 2-inch.	54	54	357	31	.....do.....	175.00	.....	.....do.....	.....
196	G. Klippel.....	.....do.....	D-9.....	1899	Bored, 2-inch.....	50	50	381	34	.....do.....	125.00	.....	.....do.....	.....
197	S. O. Houghton.....	.....do.....	D-10....	1901	Bored, 12-inch....	50	50	348	31	.....do.....	1,000.00	.....	.....do.....	40
198	F. M. Vandiver.....	.....do.....	E-9.....	.....	Bored, 7-inch.....	56	56	600	32	.....do.....	.....	.....	.....do.....	.....
199	James Keer.....	.....do.....	D-9.....	1902	Bored, 10-inch....	57	57	508	32	.....do.....	800.00	.....	.....do.....	30
200	J. Clarbour.....	.....do.....	E-8,9...	1902	Bored, 12-inch....	60	60	550	32	.....do.....	1,275.00	.....	.....do.....	†85
201	L. A. Clark.....	San Pedro.....	D-8.....	1888	Bored, 4-inch.....	60	60	400	....	Wind, artesian..	.....	.....	Domestic.....	.....
202	R. Barber.....	.....do.....	D-8.....	1873?	Bored, 7-inch.....	62	62	100	33	Hand, artesian..	.....	.....	.....do.....	.....
203	A. Dionvard.....	.....do.....	D-8,9...	1897	Hydraulic, 2-inch.	60	60	392	29	Artesian.....	165.00	.....	.....do.....	.....
204	.....do.....	.....do.....	D-8.....	1900	Bored, 10-inch....	62	58	115	....	Gas.....	200.00	.....	Irrigation.....	.....
205	J. H. Orr.....	.....do.....	D-9.....	1901	Bored, 12-inch....	55	55	550	33	Artesian.....	1,460.00	.....	.....do.....	47
206	J. Mulheron.....	.....do.....	C-9.....	1898	Bored, 2-inch.....	55	55	315	....	.....do.....	120.00	.....	Domestic; stock.	6
207	Chester Robertson....	.....do.....	D-9.....	1901	Bored, 7-inch.....	55	55	766	35	.....do.....	.....	.....	Irrigation	50
208	Talkington Bros.....	.....do.....	C-9.....	1878	.....do.....	54	54	280	33	.....do.....	700.00	.....	Domestic.....	.....
209	Mrs. Carson.....	.....do.....	C-9.....	1899	Bored, 8-inch.....	51	51	750	33	.....do.....	1,700.00	.....	Irrigation.....	†25
210	James Taylor.....	.....do.....	C-9.....	1883	Bored, 7-inch.....	55	45	426	....	Gas.....	.....	600.00	.....do.....	.....

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
211	J. L. Shepard	San Pedro	C-9	1901	Bored, 7-inch	55	50	100	36	Wind	$45.00	$150.00	Domestic	
212	J. M. Spencer	do	C 9	1900	Bored, 9½-inch	52	52	570	32	Artesian	1,500.00		Irrigation	
213	J. J. Harshman	do	B-8	1900	Bored, 12-inch	65	65	480		do	850.00			Small.
214	John Hight	do	C 9	1902	Bored, 10-inch	54	50	135		Gas	170.00		Irrigation	80
215	J. M. Shepard	do	C-9	1900	do	60	55	140		do	*1,000.00		do	115
216	Chas. A. Heath	do	C 9	1895	Bored, 2-inch	55	53	94		Hand	50.00		Stock	
217	H. A. Wittich	do	C 9	1883?	Bored, 7-inch	50	50	545	30	Artesian	2,000.00	120.00	Domestic	
218	J. M. Hart	do	B 9	1902	Bored, 12-inch	57	57	655	34	do	2,000.00		Irrigation	54
219	J. J. Harshman	do	B 8	1897	Bored, 2-inch	65	65	350	34	do			Domestic; irrigation.	
220	John Gries	do	B 8	1897	do	70	70	252	34	do	152.00		Stock	
221	W. J. Higgins	do	A 8	1868	Bored, 7-inch	78	68	114	33	Wind			Domestic; irrigation.	
222	A. M. Peck	do	C 8	1878?	do	62	57	130	42	do	200.00		Domestic; stock	
223	H. B. Rice	do	C 8	1873	do	62	57	130	38	do	200.00	100.00	Domestic	
224	John Hight	do	D 8	1898	Bored, 3-inch	61	56	70	41	Hand	35.00		do	
225	W. P. Anderson	do	C 8	1883?	Bored, 7-inch	64	64	380	38	Artesian	2,000.00		Domestic; stock	
226	F. K. Day	do	D 8	1901	Bored, 2-inch	64	64	105	36	Hand	45.00		Domestic	
227	D. R. Meyers	do	D-8	1888?	Bored, 4-inch	66	60	130	35	Wind			do	
228	R. B. Harris	do	D-8	1873?	Bored, 7-inch	63	58	100	35	do		100.00	do	
229	do	Los Cerritos	E-9	1891	Bored, 3-inch	63	58	100	35	Hand	50.00		do	
230	E. R. Collingridge	San Pedro	D-8	1885	Bored, 7-inch	67	66	132		Not raised	250.00		Not used	
231	do	do	D 8	1894	do	66	66	566	32	Artesian	1,500.00		Irrigation	42
232	A. Anderson	do	D 8	1898	Bored, 2-inch	65	65		35	Wind			Stock	

233	W. H. Craig	do	D-8		Bored, 7-inch	67	62	125	36	Hand			Domestic		
234	F. Voigt	do	D-9		Bored, 2-inch	57	52	170?	34	do			do		
235	Chester Robertson	do	D-9	1883?	do	55	55	200	37	Wind			do		
236	Mr. Kelsey	do	D-9		do	57	52		39	Hand			do		
237	Mrs. S. Buckham	do	D-9	1892?	Bored, 4-inch	55	50	100?	37	do			do		
238	J. H. Orr	do	D 9		Hydraulic, 2-inch.	55	55	550	31	Artesian			do		
239	do	do	D-9	1892	Hydraulic, 4-inch.	55	55	400	32	Hand			do		
240	do	do	D-9	1893?	Bored 7-inch	51	51	360	32	Artesian			Irrigation		
241	do	do	D 9	1899	Hydraulic, 3-inch.	51	51	360	28	do	500.00		do		
242	J. M. Shepard	do	C 9		Driven, 2-inch	56	51	110	51	Wind			Domestic		
243	Nelson Ward	do	C-9	1875?	Bored, 7-inch	53	47	175	35	do	600.00	135.00	Domestic; stock		
244	James Taylor	do	C-9	1902	Bored, 5-inch	54	46	130	38	do	100.00	65.00	Domestic		
245	Chas. A. Heath	do	C-9	1903	Hydraulic, 2-inch.	54	53	104	38	Hand	50.00		do		
246	J. J. Harshman	do	B-8	1885	Bored, 3-inch	65	61	90	40	Not raised			Not used		
247	John Gries	do	B-8			74	66	100	67	Wind			Domestic		
248	Mrs. E. Loughrey	do	A-8	1891?	Dug, 4 by 4 foot	88	64	26	77	Hand			Stock		
249	Geo. Clark	do	A-8	1901	Bored, 9¼-inch	88	68	369	29	Wind	686.00	150.00	Domestic; irrigation.		
250	Sisters of Charity	do	A-8		Bored, 7-inch	88	64	134	39	Hand			Not used		
251	Wm. Duff	do	A-8	1883	Dug, 3 by 3 foot	92	65	30	53	Wind			Domestic		
252	do	do	A-8	1902	Bored, 12-inch	90	67	340+		Artesian					
253	Compton Rural Cemetery.	do	A-9	1873	Driven, 4-inch	75	65	70	36	Wind			Irrigation		
254	J. K. Morrison	do	A-9	1880	Dug, 3-foot diameter.	95	66	35	44	do			Domestic		
255	I. W. Hellman	do	A-9		Bored, 7-inch	99	65	174	31	do			Stock		
256	J. Francis	do	A-11		Dug, 3 by 3 foot	75	23	55	105	do			do		
257	G. Delamo	do	A-11	1897	Bored, 7-inch	50	32	200+	36	do			Domestic; stock		
258	Mrs. Carson	do	B-10	1878?	Bored, 6-inch	75		250	40	Wind, gas			Domestic; irrigation.		
259	do	do	B-10	1882?	Dug, 3-foot diameter.	75	55	30	62	Wind		150.00	Irrigation		
260	W. A. Hall	do	B-8	1872?	Bored, 7-inch	62		165	35	Hand	200.00		Domestic		
261	David Gates	do	B-8	1873?	do	66	66	110	33	Artesian	250.00		do		Small.
262	do	do	B-8	1899	do	68	68	450		do	285.00		Not used		
263	do	do	B-9	1873?	do	68	68	150	33	do	250.00		Stock		
264	Los Angeles Bank	do	B-8	1897?	do	65	65	120	34	Gas			Irrigation		

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
265	Los Angeles Bank	San Pedro.....	B-8,9...	1878?	Bored, 7-inch.....	65	65	300	35	Artesian.....	.....	.....	Irrigation	.....
266	Mrs. M. Wilson.....	.....do.....	B-9.....	1873?	Dug, 8-foot diameter.	75	65	13	42	Wind.....	.....	$75.00	Domestic; stock.	.....
267	J. M. Hart.....	.....do.....	B-8.....	.....	Driven, 3-inch....	57	57	518	29	Artesian.....	.....	.....	Domestic; irrigation.	Small.
268	.....do.....	.....do.....	B-9.....	.....	Bored, 3-inch.....	57	57	316	31	.....do.....	.....	.....	Stock.....	.....
269	Pac. Electric R. R. Co.	.....do.....	B-10.....	.....	Dug, 6 by 8 foot..	52	50	15?	....	Electric motor..	.....	.....	Domestic.....	.....
271	Mrs. Geo. Carson.....	.....do.....	C-10....	1898	Driven, 2-inch....	51	51	350	33	Artesian.....	.....	.....	.....do.....	Small.
272	J Francis.....	.....do.....	C-10....	1894	Bored, 2-inch.....	50	.....	85	37	Wind.....	$35.00	100.00	Domestic; stock.	.....
273	.....do.....	.....do.....	C-10....	1903	Bored, 10-inch....	50	.....	125	....	Not installed...	.....	.....	Irrigation.....	.....
274	Miss Dominguez.....	.....do.....	B-10.....	.....	Driven, 2-inch....	50	.....	90	37	Hand.....	35.00	.....	Domestic.....	.....
275	J. M. Spencer.....	.....do.....	C-9.....	1876?	Bored, 7-inch.....	52	52	250	32	Artesian, and wind.	1,400.00	50.00	Domestic; stock.	Small.
277	T. W. Edwards.....	.....do.....	C-8.....	1896	Driven, 2-inch....	69	69	700	31	Artesian.....	.....	.....	Irrigation.....	.....
278	.....do.....	.....do.....	C-8.....	1897	.....do.....	69	69	700	31	.....do.....	.....	.....	Irrigation; stock	.....
279	J. S. Martin.....	.....do.....	C-8.....	1902	Bored, 7-inch.....	69	66	132	39	Gas.....	100.00	1,200.00	Irrigation.....	†100
280	.....do.....	.....do.....	C-8.....	1899	Bored, 2-inch.....	69	69	376	32	Artesian.....	122.50	.....	Domestic; irrigation.	†9
281	H. W. Marden.....	Los Cerritos.....	E-8.....	1901	.....do.....	65	65	100	33	.....do.....	.....	.....	Not used.....	.....
282	J. G. Bilen.....	.....do.....	D-8.....	.....	.....do.....	61	61	320?	33	.....do.....	.....	.....	Stock.....	†4
283	L. A. Clark.....	.....do.....	D-8.....	1901	Bored, 2½-inch....	61	61	128	....	.....do.....	64.00	.....	Irrigation.....	Small.
284	.....do.....	.....do.....	D-9.....	1898	Bored, 2-inch.....	61	61	310	32	.....do.....	160.00	.....	.....do.....	3
285	H. P. Epperson.....	.....do.....	E-8.....	1902	.....do.....	60	60	159	29	.....do.....	64.00	.....	Stock.....	.....
286	James Kerr.....	.....do.....	D-9.....	1902	.....do.....	57	57	400	34	.....do.....	180.00	.....	Domestic.....	Small.
287	J. Clarbour.....	.....do.....	E-8,9...	1891	Driven, 2-inch....	60	60	285	32	.....do.....	.....	.....	Irrigation.....	.....

288	....do....	....do....	E-8,9...	1891	Driven, 3-inch....	60	60	490	....	....do....	.....	.....	....do....	.....	
289	....do....	....do....	E-9.....	1891	Bored, 2-inch.....	59	59	485	31	....do....	.....	.....	Domestic.....	.....	
290	....do....	....do....	E-9.....	1891	Bored, 3-inch.....	59	59	485	....	....do....	.....	.....	Stock.....	.....	
291	F. M. Norcom.....	....do....	D-9.....	1900	Bored, 4-inch.....	53	53	485	35	....do....	300.00	.....	Domestic; irrigation.	34	
292	....do....	....do....	D-9.....	1901	....do.....	54	54	87	31	....do....	80.00	.....	Irrigation.....	25	
293	....do....	....do....	D-9.....	1901	....do.....	54	54	87	31	....do....	80.00	.....	....do.....	25	
294	J. C. Timmons.....	....do....	D-9.....	1901	Bored, 2-inch.....	53	53	465	32	....do....	235.00	.....	Domestic; irrigation.	7	
295	....do....	....do....	D-9.....	1901	....do.....	51	51	367	32	....do....	200.00	.....	Irrigation.....	7	
296	J. Stimson.....	....do....	D-9.....	1896	Bored, 3-inch.....	52	52	75	....	....do....	75.00	.....	....do.....	Small.	
297	....do....	....do....	D-9.....	1897	Bored, 2-inch.....	.....	.....	420	31	....do....	200.00	.....	Domestic; irrigation.	6	
298	S. O. Houghton.....	....do....	D-10....	1900	Bored, 2½-inch....	50	50	320	31	Artesian, wind..	.....	.....	Domestic; stock.	.....	
299	G. Klippel.....	....do....	D-9.....	1900	Bored, 2-inch.....	51	51	355	32	Artesian.....	125.00	.....	Irrigation.....	6	
300	....do....	....do....	D-10....	1899	....do.....	51	51	280?	33	....do....	105.00	.....	....do.....	4	
301	....do....	....do....	E 10....	1897	....do.....	52	52	350	33	....do....	125.00	.....	Stock.....	4	
302	....do....	....do....	D, E-9..	1897	....do.....	52	52	86	26	....do....	75.00	.....	Domestic; stock.	.....	
303	G. H. Bixby.....	....do....	D-10....	1903	Bored, 12-inch....	50	50	907	26	....do....	.....	.....	Irrigation.....	30	
304	....do....	....do....	D-10....	1880	Bored, 4-inch.....	49	49	400?	37	....do....	.....	.....	Domestic.....	.....	
305	....do....	....do....	D-10....	1898	Bored, 2-inch.....	49	49	400?	28	....do....	.....	.....	....do.....	.....	
306	....do....	....do....	C-10....	1898	....do.....	49	49	420	32	....do....	.....	.....	Domestic; irrigation.	Small.	
307	....do....	....do....	C-10....	1898	....do.....	49	49	440	32	....do....	.....	.....	Domestic; stock.	Small.	
308	....do....	....do....	D-11....	1890?	Bored, 7-inch.....	50	50	300?	31	....do....	.....	.....	.....	1	
309	....do....	....do....	D-11....	.....	....do.....	49	49	350?	....	....do....	.....	.....	Not used.....	.....	
310	....do....	....do....	D-10....	1903	Bored, 12-inch....	51	51	682	26	....do....	.....	.....	Irrigation.....	29	
311	....do....	....do....	D-10....	1890?	Bored, 2-inch.....	52	52	350	....	....do....	.....	.....	Stock.....	Small.	
312	J. Worst.....	....do....	E-10....	1900	....do.....	54	54	400	30	....do....	140.00	.....	Irrigation; stock	.....	
313	....do....	....do....	E-10....	.....	Bored, 3-inch.....	54	54	160	32	Hand, artesian..	.....	.....	Irrigation.....	.....	
314	F. E. Green.....	....do....	E-10....	1899	Bored, 2-inch.....	56	56	398	33	Artesian.....	160.00	.....	....do.....	.....	
315	....do....	....do....	E-10....	1889	Bored, 7-inch.....	55	55	85	26	Wind.....	.....	.....	Domestic; irrigation	.....	
316	G. W. Calionette.....	....do....	E-9.....	1899	Bored, 2-inch.....	61	61	368	31	Artesian.....	300.00	.....	Irrigation.....	.....	
317	Ed White	....do....	E-9.....	1888	Bored, 6-inch.....	60	60	150	30	....do.....	150.00	.....	Domestic.....	.....	
318	Z. Lent.....	....do....	E-9.....	.....	Bored, 2-inch.....	55	55	330	32	....do....	.....	.....	Irrigation; domestic.	Small.	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
319	A. E. Matson	Los Cerritos	E-9	1900	Bored, 3-inch	61	61	400	28	Artesian	$200.00			
320	do	do	E-9	1899	Bored, 2-inch	61	61	380		do	125.00		Irrigation	
321	Mr. Hamilton	do	E-9		do	60	60	90		do			Domestic; stock	
322	do	do	E-9		Bored, 4-inch	60	60	103	29	do			Stock	4
323	do	do	E-9		Bored, 6-inch	60	60	200	28	do			Irrigation	Small.
324	Z. Lent	do	E-9	1897	Bored, 2-inch	55	55	350?	32	do			Stock; irrigation	
325	do	do	E-9	1897	do	55	55	100+	33	do			Irrigation; stock	
326	R. H. Parker	do	E-9	1899	do	57	57	567	32	do	200.00		Irrigation	4
327	Lydia Withers	do	E-9	1899	Bored, 4-inch	61	56	30	34	Wind			Stock	
328	H. A. Davis	do	E-9	1895	Bored, 2-inch	63	63	151		Artesian	45.45		Irrigation	
329	H. P. Epperson	do	E-9	1897	do	63	63	631	26	do	300.00		do	
330	John MacIlmoil	do	E-8	1898	do	66	66	610	25	do	250.00		do	1
331	do	do	E-8	1898	do	66	66	210	25	do	100.00	$200.00	Irrigation; domestic	1
332	M. C. Isom	do	E-8	1895	do	70	70	158	25	Wind, artesian	100.00	100.00	Domestic	
333	E. Mason	do	E-8	1890	Bored, 5-inch	69	69	140	28	Hand	150.00		Stock; domestic	
334	do	do	E-8	1890	Bored, 4-inch	69	69	165	28	do	150.00		Domestic; stock	
335	F. O. Sward	do	E-8	1899	Bored, 2-inch	70	70	180	31	Wind			Domestic	
336	do	do	E-8	1903	do	69	69	169		Artesian	75.00?		Irrigation	
337	M. J. Luccock	do	E-8	1890	Bored, 4-inch	73	73	280	26	Hand	200.00+		Domestic	
338	Chas. Roberts	do	E-8	1892	Bored, 2-inch	72	71	114	26	Wind	15.00	30.00	do	
339	do	do	E-8	1901	Bored, 3-inch	72	72	140		Wind, gas	93.00	200.00	Irrigation	
340	Clearwater Cooperative Creamery	do	E-8	1902	Bored, 2-inch	76	767	160	27	Gas, artesian	50.00		Domestic	

341	E. A. Rodgers	do	E-8	1903?	do	75	75	125	26	Artesian	50.00	Stock	
342	S. N. Jennings	do	E-7	1899	Bored, 7-inch	74	.....	130	26	Wind		Domestic	
343	do	do	E-7	1900	Bored, 10-inch	77	77	155	25	Hand, artesian	200.00	Irrigation; stock	
344	do	do	E-8	1891	Bored, 7-inch	70	70	351	26	Artesian	200.00?	Stock	
345	J. V. Stewart	do	E-7	1897	Bored, 2-inch	77	77	150	25	do	70.00	Stock; domestic	
346	do	do	E-7	1897	Bored, 3-inch	79	79	150	25	do	70.00	Stock; irrigation	10
347	C. Hardue	do	E-7	1898	Bored, 10-inch	75	75	163	....	Gas, artesian		Irrigation	3
348	do	do	E-7	1895	Bored, 7-inch	77	77	150	25	Artesian		Not used	†60
349	L. Stiner	do	E-7	1901	do	75	75	150	26	Hand, artesian	180.00	Domestic; irrigation	
350	do	do	E-7	1899	Bored, 2-inch	75	75	150	25	Artesian	60.00	Stock	
351	Henry Carson	do	E-7	1897?	Bored, 4-inch	75	75	140	26	do	80.00	Domestic	Small.
352	do	do	E-7	1897?	Bored, 6-inch	75	75	140	27	do	125.00	Not used	
353	R. A. McCurdy	do	E-7	1897	Bored, 7-inch	80	80	150	27	do		Domestic; stock	Small.
354	Geo. Hinman	do	E-7	1891	Bored, 4-inch	80	80	156	26	do	125.00	Domestic	14
355	H. J. Kent	do	E-7	1898?	Bored, 7-inch	79	79	150	27	do	150.00?	do	
356	J. M. Williams	do	E-7	1902	Bored, 2-inch	81	81	128	26	do	53.00	do	
357	Geo. A. Williams	do	E-6,7	1899	do	81	81	117	26	do		do	
358	P. Gunn	do	E-7		do	81	81	130	26	do		do	
359	Orr & Orr	San Antonio	D-8	1894	Bored, 7-inch	71	71	180	....	do		do	
360	do	do	D-8	1894	Bored, 9½-inch	71	71	390	33	do		Irrigation	26
361	Carpenter estate	San Pedro	D-7	1897?	Bored, 10-inch	77	77	230	35	Gas, artesian		do	†155
362	do	do	D-7	1897?	do	74	74	230	26	do		do	
363	do	do	E 7		Bored, 8-inch	76	77	161	....			Not used	
364	do	do	D 8		Bored, 10-inch	73	73	.....	32	Hand		Domestic; stock	
365	Chas. F. Williams	do	D-8	1890	Bored, 7-inch	65	62	147	33	do		Domestic	
366	J. H. Williams	do	D-8	1888	do	72	71	186	....	Artesian	400.00	do	
367	Compton City school district.	do	D-8	1891	Hydraulic, 3-inch.	72	.....	150	33	Hand		do	
368	John Morton	do	D-8	1902	Bored, 7-inch	74	73	133	....	Gas	150.00	Irrigation	125
369	H. H. Taylor	do	C-8	1890	Bored, 2-inch	71	71	250	34	Artesian	350.00	Domestic	1
370	J. J. Morton	do	C-7	1876	Bored, 7-inch	75	70	360	....	Gas	2,000.00	Irrigation	†100
371	do	do	C-7	1896	Hydraulic, 2-inch.	72	72	133	32	Artesian	200.00	Domestic	
372	do	do	C-8	1883	Hydraulic, 3-inch.	72	69	130	33	Gas	200.00	Irrigation; domestic	125
373	Mrs. A. Mayo	do	C-8	1875	Bored, 6-inch	72	68	150	33	do		Domestic	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
374	Mrs. A. Mayo	San Pedro	C-7	1883	Bored, 7-inch	75	70	150	35	Gas	$200.00		Irrigation	†75
375	J. A. Howie	do	C-7		do	72	69	125	35	Wind	200.00	$100.00	Stock; domestic	
376	G. W. Neece	do	C-8	1891	do	75	75	150		Gas	250.00	800.00	Irrigation	125
377	do	do	C-7	1890	do	72	68	150		Wind	250.00	150.00	Domestic	
378	Mr. Marlowe	do	D-7	1877	do	80	77	150	34	Hand			do	
379	Sherman estate	do	D-7	1892	Bored, 5-inch	80	76	150	34	do			do	
380	M. A. Rozelle	do	D-7		Bored, 2-inch	81		117	37	do	35.00		do	
381	Chas. Tibbetts	San Antonio	D-7	1902	Bored, 10-inch	82	81	162	34	Gas	275.00	800.00	Irrigation	75
382	do	do	D-7	1883?	Bored, 5-inch	82	77	150?	34	Hand			Domestic	
383	Geo. W. Phelan	do	E-6,7	1897?	Bored, 9-inch	82	82	680	25	Gas			Irrigation	†150
384	do	do	E-7	1897?	Bored, 7-inch	82	81	300+	25	do			do	
385	do	do	E-7	1897	Bored, 2-inch	82		160		Artesian			Not used	
386	do	do	E-7,8	1897	Bored, 8-inch	82	81	300					do	
387	do	do	E-7		Bored, 7-inch	80		250	26	Hand			Domestic	
388	do	do	D-7		Bored, 2-inch	80		160		Artesian			Stock	
389	E. E. Beazley	do	D-7		do	80	80	160		do			Not used	
390	F. C. Carroll	do	D-7	1883	Bored, 7-inch	84	81	180	33	Gas		600.00	Irrigation	75
391	V. H. Stillwell	do	D-6	1902	Bored, 10-inch	88	88	176	35	do	260.00	800.00	do	100
392	T. H. Abbott	do	D-6	1900	do	90	88	169	33	do	300.00	825.00	do	
393	B. T. Rozelle	do	D-6	1895	Bored, 12-inch	87	86	169		do	350 00		do	200
394	C. H. Watts	do	E-6	1891	Bored, 4-inch	87	83	140	25	Wind	150.00		Domestic	
395	do	do	D-6	1893	Bored, 7-inch	87	87	300					Not used	
396	Dr Davis	do	E-5	1891	Bored, 4-inch	96	88	150	30	Hand	40.00		Domestic	

397	Alexander Gunn	do	E-5	1903	Bored, 12-inch	100	100	625	23	Artesian	1,600.00		Irrigation		54
398	do	do	E-5	1899	Bored, 4-inch	100	100	556		do			Not used		
399	do	do	D-5	1890	Bored, 6-inch	85?	85	550?	31	do			Stock		
400	R. Gilhousen	do	E-5	1902	Bored, 10-inch	98	91	154	27	Gas	350.00	950.00	Irrigation		85
401	do	do	E-5	1898	Bored, 2-inch	98	91	128	27	Wind		175.00	Domestic		
402	D. Lane	do	E-6	1890	Bored, 12-inch	90	90	757	25	Artesian	2,000.00		Irrigation		61
403	J. B. Norton	do	D-5	1880?	Bored, 7-inch	100		200?	41	Wind			Domestic		
404	L. Snodgrass	do	C-5	1897	Bored, 12-inch	103	103	800	34	Artesian	4,000.00		Irrigation		35
405	do	do	D-5	1895	Bored, 10-inch	103	99	150	36	Gas		1,400.00	do		130
406	do	do	D-5	1890	Bored, 8-inch	103	94	150	38	Wind			Domestic		
407	A. W. Miller	do	D-5	1902	Bored, 10-inch	104	99	176	39	Gas	350.00	1,650.00	Irrigation		125
408	H. Lewis	do	D-5	1883	Bored, 7-inch	104	99	140	37	Hand			Domestic		
409	G. W. Tweedy	do	D-5	1899	Bored, 4-inch	105	100	155	33	Wind	300.00	150.00	do		
410	L. D. Tweedy	do	D-4	1900	Bored, 12-inch	118	110	698		Gas	*4,500.00		Irrigation		200
411	do	do	E-5	1884?	Bored, 10-inch	104	103	250?	38	Wind			Domestic		
412	do	do	D-5	1903	Bored, 5-inch	109	101	145		Hand	145.00		do		
413	H. W. Wythe	do	D-4	1901	Bored, 10-inch	105	99	174		Wind, gas	300.00	300.00	Domestic; irrigation.		50
414	Mrs. Wilbur Woods	do	D-4	1897	Bored, 4-inch	104	99	83		Hand			Not used		
415	C. O. Humphreys	do	D-4		Bored, 2-inch	111		85?	39	Wind			Domestic; irrigation.		
416	Mr. White	do	D-4	1901	Bored, 12-inch	112	107	530	31	Hand	1,600.00		Domestic		
417	do	do	D-4		Bored, 2-inch	112		85?		do			Not used		
418	Samuel Martin	do	C-5		Bored, 7-inch	105	105	160	39	Artesian, gas			do		
419	do	do	C-5		do	105	105	160		Artesian			do		
420	K. Swantek	do	C-5	1890?	Bored, 4-inch	105	105	150?		do			Domestic		
421	Samuel Martin	do	C-5	1880	Bored, 7-inch	100	100	160	38	Wind	300.00		do		
422	do	do	C-5	1880	do	98	98	160	41	Artesian	300.00		Irrigation		
423	do	do	C-5	1895?	do	98	98	160	40	do			do		60
424	William Lynch	do	C-6	1876	Bored, 6-inch	97	97	172	37	do	275.00		Domestic		6
425	Mr. Kincaid	do	C-6	1896	Bored, 4-inch	93	90?	180	37	Hand			do		
426	Fred Niel	do	D-6	1895?	Bored, 7-inch	91		180		Gas	200.00		Irrigation		
427	Mr. Carres	do	D-6		do	90	84	180	38	Hand			Stock		
428	Frank Beck	do	D-6	1895?	Bored, 2-inch	93		170		do			Domestic		
429	H. W. Lewis	do	C-6	1895	Bored, 7-inch	91	91	130	37	Hand, artesian	150.00		Irrigation; domestic.		25

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
430	Chas. Bates	San Antonio	C-6	1902	Bored, 2-inch	91	91	130	37	Hand	$55.00		Domestic	
431	Lugo school district	do	C-6	1898	do	92	92	130	37	Artesian	55.00		do	
432	B. Eberly	do	C-6	1902	do	92	92	130	36	Hand	60.00		do	
433	E. W. Lewis	do	C-6	1875	Bored, 7-inch	91	91	130	38	Artesian	130.00		Domestic; irrigation.	12
434	do	do	C-6	1885	do	90	93	130		do	130.00		Irrigation	19
435	Joseph Hohn	do	C-6	1894?	do	90	90	130	41	do			Domestic	
436	G. F. Daetweiler	do	C-6	1894	do	90	90	133	41	do			Domestic; irrigation.	Small.
437	do	do	C-6		do	90	90	130		do			Irrigation	Small.
438	John Eichholzer	do	B-6	1897?	Bored, 4-inch	91	91	133	44	do			Stock	
439	G. F. Daetweiler	do	B-6	1898?	do	91	91	133	46	do			do	
440	C. H. Sessions	do	B-5		Bored, 7-inch	98	98	160		do			Irrigation	Small.
441	do	do	B-5	1898?	Bored, 10-inch	99	99	160	51	do			do	2
442	do	do	B-5	1898?	do	99	99	160	51	do			do	2
443	do	do	C-5		Bored, 12-inch	95	95	350		do			Domestic	
444	do	do	B-6	1900?	do	88	88	380	36	do			Irrigation	
445	do	do	B-6	1900?	do	88	88	380	35	do			do	†40
446	do	do	B-6		Bored, 6-inch	85	85	140		do			Not used	
447	John Sinn	do	B-6	1901	Bored, 7-inch	88	88	325	32	do	600.00		Domestic; irrigation.	7
448	Frank Wall	do	C-6	1901	Bored, 2-inch	88	88	130	30	do	50.00		Domestic	4
449	James Nichols	do	C-6	1883?	Bored, 6-inch	92	92	350	36	Artesian, wind		$125.00	do	
450	E. Fickewirth	do	C-6	1883	Bored, 2-inch	91	91	130	38	Artesian, hand			do	

451	W. B. Finch	do	C-6		do	90	90		37	Hand			do	
452	Chas. Tibbetts	do	C-6	1887	Bored, 4-inch	87	87	140	37	do			do	
453	H. Catey	do	C-6	1898	Bored, 12-inch	88	88	382	35	Artesian	1,200.00		Irrigation	†100
454	do	do	C-6	1878?	Bored, 7-inch	88	88	140		do			Not used	
455	Chas. Tibbetts	do	C-6	1891	do	87	87	140		do				
456	H. Musselman	do	C-7	1885	do	85	85	145	38	Wind	200.00	175.00	Domestic	
457	O. J. Williams	do	C-7	1885	Bored, 9-inch	85	84	140	36	Hand			do	
458	J. L. Wininger	do	C-6	1880?	Bored, 7-inch	87	84	140	36	do			do	
459	Fred Daetweiler	do	C-7	1901	Bored, 2-inch	84	84	380	35	Artesian	150.00		do	
460	F. M. Kincaid	do	D 7	1902	do	83		140	38	Hand	75.00		do	
461	J. O. Waite	do	D-7	1888?	Bored, 7-inch	83	83	450	35	Artesian			do	
462	John T. Daetweiler	do	C-6	1888	do	87	87	135	41	do	240.00		Irrigation	60
463	do	do	C-6	1878	do	87	87	135	41	do	300.00		do	60
464	G. Yeoman	do	C-7	1901	do	87	86	200	37	Wind		125.00	Stock; domestic	
465	do	do	C-7	1897	Bored, 10-inch	87	87	325	35	Artesian	600.00		Irrigation	80
466	Eureka Cooperative Creamery.	do	C-7	1894	Bored, 4-inch	85	85	130	35				Domestic	
467	M. P. McDonald	do	C-7	1887	Bored, 7-inch	84	84	130	37	Artesian			do	42
468	do	do	C-7	1897	do	84	84	335	33	do	540.00		Irrigation	50
469	H. M. Williams	San Pedro	C-7	1894?	Bored, 3-inch	82	82	140	33	do			Domestic	
470	S. Stockwell	San Antonio	C-7		Bored, 7-inch	80	80	145	38	do			Not used	
471	Mrs. Hastings	San Pedro	C-7	1899	do	78	78	350	35	do	750.00		Irrigation	40
472	do	do	C-7	1895	do	71	71	135	40	do	500.00		Domestic	Small.
473	do	do	C-7	1895	do	71	71	135		do	500.00		Not used	
474	M. Elfman	do	C-7	1897	Bored, 2-inch	77	77	250?	33	do	150.00		Domestic; stock	Small.
475	N. L. McIntosh	do	C-7	1896	Bored, 7-inch	77	77	315		do	500.00		Not used	7
476	Mrs. A. A. Williams	do	C-7	1894	Bored, 2-inch	78	78	350	33	do	555.00?		Domestic	
478	R. B. Easley	do	C-7	1902	Bored, 10-inch	79		150	35	Wind	250.00		do	
479	J. H. Easley	do	C-7	1891	Bored, 3-inch	81	81	320		Artesian			Not used	
480	A. W. Miller	do	C-7		Bored, 8-inch	77		150					Irrigation	†85
481	J. L. Johnson	do	C-8	1899	Bored, 9½-inch	71	71	400	33	Artesian	800.00		do	†40
482	A. R. McIntosh	do	C-7	1898	Bored, 2-inch	78	75	80	41	Hand	40.00		Domestic	
483	F. Vennass	do	C-7	1880?	Bored, 7-inch	75	75	150		Gas	185.00		Irrigation	65
484	do	do	C-7	1897	do	74	74	150	37	do	150.00		do	65
485	do	do	B-7	1899	do	75	75	150	40	Artesian	150.00		do	76

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
486	F. Walton	San Pedro	C-7	1899	Bored, 7-inch	74	74	150	39	Artesian	$150.00		Irrigation	19
487	F. E. Stockwell	San Antonio	C 7	1883	do	83	83	148	41	do	250.00		do	†60
488	do	do	C-6	1891	do	83	83	158	40	do	180.00		do	†60
489	do	do	C-7	1881	do	82	82	147	40	do	250.00		do	
490	H. C. Carson	San Pedro	C-7	1888	Bored, 6-inch	77	77	163	39	Hand, artesian	200.00		Irrigation; stock	
491	L. Abbott	do	C-7	1885?	Bored, 7-inch	80	80	150?	42	Artesian	200.00		do	
492	E. Miller	do	C-7	1875?	do	75	75	136	43	do	136.00		Domestic	Small.
493	Wm. McDivitt	do	B 7	1890	do	80	80	145		do	150.00		Irrigation	25
494	do	do	B 7	1901	Bored, 10-inch	80	80	150	41	do	500.00		do	†25
495	do	do	B 7	1902	do	78	78	150	41	do	500.00		do	25
496	do	do	B 7	1888	Bored, 2-inch	78	78	150	39	Artesian, hand	60.00		Stock; domestic	Small.
497	J. R. Hann	do	B-7	1902	do	77	77	233	39	Artesian	104.50		Domestic; irrigation	2
498	J. S. Palmer	do	B 7	1883?	Bored, 7-inch	76	76	260	33	do			Domestic	
499	G. Palmer	do	B-8	1893	Bored, 2-inch	67	67	228		do	100.00		Domestic; stock	Small.
500	J. A. McMillan	do	B-7	1901	do	75	75	220	34	do	100.00		Domestic; irrigation	
501	R. H. Dinsmore	do	C-8	1881	Bored, 7-inch	71	71	130	42	Hand			Domestic	
502	C. E. Wood	do	C 8	1899	Bored, 2-inch	73	73	310	34	Artesian	135.00		Domestic; irrigation	6
503	A. Sloane	do	C-7	1900	Bored, 9½-inch	73	73	339	33	do	600.00		Irrigation	†50
504	do	do	C-8	1898	Bored, 3-inch	70	70	275	33	do	135.00		Domestic	12
505	L. A. Leavitt & Co	do	C-8	1894	Bored, 7-inch	68	68	290	35	do	300.00		Irrigation	
506	H. J. Mayo	do	B-8	1900	do	67	67	280	33	do	700.00		do	20
507	do	do	B-8	1900	Bored, 2-inch	68	68	280	33	do	300.00		Domestic	Small.

508	W. G. Legg	do	B-8	1899	Bored, 4-inch	70	70	260	34	do	200.00		do	
509	Mrs. J. Spencer	do	B-8	1896	Bored, 2-inch	70	70	160	37	do	100.00		do	
510	C. J. Clark	do	B-8		do	69	69	200	35	do			Domestic; stock	Small.
511	do	do	B-8		Bored, 3-inch	70	70	200	35	do			Irrigation	†10
512	do	do	B-8		Bored- 7-inch	70	71		34	do			Not used	
513	J. F. Norton	do	B-8	1895	Bored, 3-inch	69	69	230	35	do			Domestic	Small.
514	L. Gully	do	B-8		Bored, 2-inch	60	60		34	do			do	Small.
515	Chas. Wright	do	B-8	1897	Bored, 6-inch	67	67		35	do			Irrigation; domestic.	†30
516	L. Gully	do	B-8		Bored, 1-inch	63	63		35	do			Irrigation	
517	Southern Pacific Co	do	B-8	1897	Bored, 7-inch	66	66	400	33	do			Domestic	Small.
518	do	do	B-8	1888?	Bored, 2-inch	67	67	180	33	do			do	3
519	R. H. Wilson	do	B-8	1893	Bored, 7-inch	66	66	225	33	Artesian, wind	500.00		do	†1
522	J. Malcom	do	B-8	1897	do	70	70	310	35	Artesian	375.00		Irrigation	106
523	Michael Ruffner	do	B-8	1895	Bored, 2-inch	67	67	193	33	do	100.00		Domestic	Small.
524	do	do	B-8	1868?	Bored, 6-inch	67	67	216	33	do	900.00		do	35
525	do	do	B-8	1882?	do	66	66	230	35	do	900.00		Domestic; stock	18
529	S. M. Bise	do	B-8	1899	Hydraulic, 2-inch	68	68	223	33	do	110.00		Stock	
531	Sarah I. Wigginton	do	B-8	1885?	Bored, 7-inch	67	67	250	32	Gas	500.00		Domestic	1
532	J. D. McNiel	do	B-8	1898	Bored, 2-inch	70	70	258	34	Artesian	230.00		Domestic; irrigation	
533	Wm. Shamrak	do	B-8	1891	Bored, 3-inch	70	70	205	35	Artesian, wind	205.00	$140.00	Domestic	Small.
534	B. Walton	do	B-8		Bored, 2-inch	70	70		35	Wind	125.00		do	
535	Methodist Episcopal parsonage.	do	B-8	1878?	Bored, 7-inch	70	70	100	34	Artesian			do	
536	E. D. Morden	do	B-8	1897	Hydraulic, 2-inch	68	68	210	35	do	87.50		do	Small.
538	Compton City school district.	do	B-8	1893	Bored, 2-inch	70	70	200?	34	do	100.00		do	
539	Robert Shear	do	B-8	1895	do			255	33	do	125.00		do	
540	G. W. Rodgers	do	B-8	1894	do			225?	35	do	100.00		do	
541	J. D. Gill	do	B-8	1900	do	67	67	200?	35	do	100.00		do	
542	E. M. Yankee	do	B-8		do	69	69	210?	33	do	105.00		Domestic; irrigation.	
543	John Boyer	do	B-8	1903	do	70	70	381	34	do	202.50		Stock; domestic	
544	H. M. Dillon	do	B-8	1895	do	69	69	200	33	do	110.00		Domestic	
545	Thos. J. Peachey	do	B-8	1897	do	69	69	160	33	do			do	Small.
546	G. D. Barron	do	B-8		Bored, 7-inch	71	71		32	Hand			do	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
547	Robert Shear	San Pedro	A-7	1887	Bored, 7-inch	76	76	255		Artesian			Irrigation	
548	do	do	A-7	1895	do	75	75	255	33	do	$250.00		do	†60
549	B. F. Lasswell	do	A-8	1895	Bored, 2-inch	75	75	175	34	Artesian, hand	75.00		Domestic	Small.
550	John Stevens	do	A-8	1885	Bored, 7-inch	79	74	440	31	Wind	1,000.00		do	
551	O. S. Long	do	A-8		do	80	77	175	35	Hand			do	
552	A. C. Bird	do	A-8		do	77	75	175	41	Wind			do	
553	Mrs. Minnie Stuart	do	A-8	1885	do	81	76	160	33	do			do	
554	A. C. Bird	do	A-7	1898?	Bored, 2-inch	76	76	175	35	Artesian, hand			do	
555	Chas. E. Marble	do	A-8	1870?	Bored, 7-inch	84	78	160?	34	Wind			do	
556	C. A. Conklin	do	A-8	1873?	Bored, 6-inch	87	70	160	36	do			do	
557	H. C. Kelsea	do	A-7	1878	Bored, 7-inch	93	69	200	33	Gas	200.00	$1,000.00	Irrigation	40
558	Sam Flick	do	A-7	1887	do	93	68	200	34	Wind	200.00		Domestic	
559	P. Commerce	San Antonio	A-7	1899	Bored, 10-inch	92	72	240	33	Gas	*1,000.00		Irrigation	†40
560	O. Dehetre	San Pedro	A-7	1883	Bored, 7-inch	84	74	200	35	Wind		125.00	Domestic	
561	do	do	A-7	1888	do	84	71	200					Not used	
562	T. H. Cressey	San Antonio	A-7	1886	do	84		150	38	Wind	250.00		Domestic; irrigation.	
563	Benj. Lee	San Pedro	A-7	1899	Hydraulic, 10-inch	85	85	260	35	Artesian	425.00		Irrigation	Small.
564	do	do	A-7	1880?	Bored, 6-inch	82	79	100	40	Wind			Domestic	
565	M. C Matthesen	do	A-7	1895	Bored, 2-inch	80	80	167	32	Artesian	67.00		Domestic; stock	Small.
566	S. W. Imbler	do	A-7	1895	do	79	79	180	33	do	90.00		Domestic	
567	S. J. Hull	do	A-7	1878	Bored, 7-inch	79	79	160	34	do			do	
568	D. M Crum	do	B-7	1885	do	78	78	209	34	do			do	†7
569	Mrs. Mary Harrison	do	B-7	1898	Bored 12-inch	78	78	254	33	do	500.00		Irrigation	22

570	Isaac Walton	do	B-7	1890?	Bored, 7-inch	77	77	225?	33	do			do	2
571	Mrs. M. Safstrom	do	B-7		Bored 2-inch	72	72		35	do			Irrigation; domestic.	Small.
572	J. Dimler	do	B-7	1902	do	69	69	253	35	do	100.00		Domestic	Small.
573	C. Mealey	do	B-7	1888	Bored, 4-inch	75		100	37	Hand	100.00		do	
574	J. Kelso	do	B-7	1902	Bored, 2-inch	67	67	237	35	Artesian	115.00		do	
575	John Flood	do	B-7		Bored, 4-inch	68	68	260	37	Hand			do	
576	L. F. Stockwell	San Antonio	B-6	1878	Bored, 7-inch	78	78	525	33	Artesian			Irrigation	†3
577	do	do	A-6	1896	do	79	79	500		do	1,200.00		do	†5
578	Dr. A. M. McCulloh	do	B-7	1902	Bored, 10-inch	79	79	269	33	do	500.00		do	†55
579	do	do	B-7	1890?	Driven, 2-inch	73	73	75		do	35.00		Not used	
580	Mrs. Banning	do	B-6		Bored, 7-inch	81	81		38	do			Domestic; irrigation.	
581	C. H. Sessions	do	B-6		do	81	81	150?		do			Stock	
582	E. Northcote	do	B-6	1892?	Bored, 2-inch	86	86		41	do			Domestic	
583	Mr. Brown	do	B-6		Bored, 4-inch	89	89		41	do			do	
584	E. E. Galbreth	do	B-5		Bored, 7-inch	93	93	64	47	do			do	Small.
585	Omri Bullis	do	B-6	1902	Bored, 2-inch	91	91	40	51	do	42.00		Domestic; irrigation.	
586	do	do	B-5	1883	Bored, 7-inch	93	93	82	47	do	80.00		Stock	Small.
587	E. E. Galbreth	do	B-5		do	94	94	72	45	do			Domestic	Small.
588	L. Snodgrass	do	B-5	1897	Bored, 8-inch	98	98	400?	42	Artesian, gas	500.00		Irrigation	
589	F. Hoppe	do	B-5	1883	Bored, 6-inch	99	99	85	49	Artesian			Stock	Small.
590	do	do	B-5	1883	Bored, 5-inch	105	105	85	47	do			do	2
591	A. Gunn	do	B-5		Bored, 6-inch	97	97	96	51	do			Domestic	†6
592	Sessions & Collins	do	B-5		Bored, 7-inch	100	100	100?		do			Stock	2
593	do	do	B-5		Bored, 5-inch	100	100	130?	49	do			do	Small.
594	Unknown	do	B-5	1880	Bored, 7-inch	103	103	135	40	do	300.00		do	Small.
595	Mr. Gilky	do	C-5	1901	do	100	100	150	35	do	200.00		Irrigation	12
596	Robert Tweedy	do	B-5	1896	Bored, 4-inch	107	107	90	48	Wind	75.00	300.00	Domestic	
597	ames Tweedy	do	B-4	1902	do	116	116	105	40	do	81.00	72.00	Stock	
598	Mrs M. Tweedy	do	C-4	1893	Bored, 6-inch	116	116	130	38	Artesian, wind	150.00	35.00	do	Small.
599	Thos. Tweed	do	B-4	1902	Bored, 4-inch	118	118	106	40	Hand	81.00		do	
600	Robert Tweedy	do	C-4	1902	do	114	114	105	38	Wind	81.00	75.00	Domestic; stock	
601	J. E. Tweedy	do	C-4	1893	Bored, 7-inch	119	118	125	38	Artesian, hand	100.00	5.00	Stock; domestic	
602	C. Snodgrass	do	B-4	1901	Bored, 10-inch	113	110	125	40	Gas	200.00		Irrigation	†60

Wells in the Downey quadrangle—Continued.

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						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
603	C. Snodgrass	San Antonio	B-4	1880	Bored, 6-inch	112	112	90	42	Artesian	$100.00		Domestic	Small.
604	do	do	A-4	1883	Bored, 7-inch	111	111	96		do	100.00		Irrigation	
605	Phil. M. Crockett	do	B-4	1893	Bored, 4-inch	120	116	79	52	Wind		$200.00	Domestic; irrigation.	
606	do	do	A-4	1893	Bored, 7-inch	113	112	200	38	Artesian			Irrigation	
607	Mrs. Antoni	do	B-4	1893	do	120	119	113	41	do			Domestic; irrigation.	
608	do	do	A-4	1895	Bored, 10-inch	116	115	104	40	do				
609	T. A. Tweedy	do	B-4	1888	Bored, 6-inch	123	118	140	45	Wind		200.00	Domestic	
610	C. F. Wood	do	A-7	1891	Bored, 7-inch	82	82	238	35	do			Irrigation; domestic.	
611	F. L. Walton	do	A-7	1900	Bored, 10-inch	85	83	240	37		500.00		Irrigation	
612	Mrs. Botiyear	do	A-7	1890?	Bored, 6-inch	85	85	225	37	Artesian, hand			Domestic; irrigation	
613	W. C. Walton	do	A-6	1895	Bored, 2-inch	87	86	228	37	Wind	110.00	150.00	Domestic	
614	J. E. Lodge	do	A-6		Bored, 7-inch	88	87	225?	32				Not used	
615	D. H. Drinkerhoff	do	A-6	1900	do	91	90	243		Gas	300.00	750.00	Irrigation	100
616	Mrs. Mary Banning	do	A-6	1883	do	90	90	252	34	Wind	300.00		Domestic	
617	E. S. Gunby	do	A-6	1888	do	94	94	250		Gas	500.00	600.00	Irrigation	60
618	do	do	A-6	1890?	do	93	93	325?	35				Not used	
619	Mrs. Westem	do	A-6	1878	do	92	92	100	45	Wind	100.00	150.00	Domestic; stock	
620	do	do	A-6	1878	do	93	93	500	33		1,000.00			
621	do	do	A-6	1878	do	92	92	100		Artesian	100.00		Stock	Small
622	Wm. Stahl	do	A-6		Bored, 6-inch	93	93	250	38				Domestic; irrigation.	

623	W. F. Ruoff	do	A-6	1887	Bored, 7-inch	94	93	100	48	Hand			Domestic		
624	J. C. Reece	do	A-5	1890?	do	94	93	225	40	do			Domestic; irrigation.		
625	M. MacFarland	do	A-5,6		Bored, 4-inch	98	93	90	44	Wind	50.00	150.00	Domestic		
626	Mrs. J. M. Avila	do	A-5	1883	Bored, 7-inch	96	96	85	45	Artesian			do		
627	Jesus Leon	do	A-5	1891	Bored, 6-inch	97	97	85	45	do	85.00		Domestic; irrigation.	Small.	
628	C. W. Rice	do	A-5	1892	Bored, 7-inch	97	97	80	46	do	80.00		Irrigation	2	
629	Mrs. F. Talamantos	do	A-5		do	100	95	80	41	Hand	75.00				
630	Strong & Nickinson	do	A-5		do	102	94	72	38	do	70.00		Domestic		
631	do	do	A-5	1897	Bored, 10-inch	102	103	400	25	Artesian			Not used		
632	do	do	A-5	1890?	Bored, 4-inch	100	101	75	49	do	75.00		Stock	Small.	
633	do	do	A-5	1897	Bored 10-inch	100	101	400	25	do			do	Small.	
634	do	do	A-5	1897	Bored, 7-inch	100	101	400	25	do			do	Small.	
635	J. G. Bellew	do	A-5	1882	do	100	100	73	49	do	100.00		Stock; irrigation.	8	
636	do	do	A-5	1900	do	98	98	75	50	do	100.00		Irrigation	17	
637	do	do	A-5	1898	do	99	99	75	49	do	100.00		do	12	
638	Isaac Walton	do	A-5	1899	Bored, 4-inch	100	100	75	49	do	50.00		Domestic	Small.	
639	G. W. Kennedy	do	A-5	1888	Bored, 7-inch	101	101	80	51	do	100.00		do	Small.	
640	Mr. Wood	do	A-5		Bored, 4-inch	102	102	75	52	do			do		
641	Alfred Bellew	do	A-5		Bored, 7-inch	105	105	75	52	do			do		
642	Mr. Isaac Walton	do	A-5		do	105	105	75	52	do	100.00		do	Small.	
643	do	do	A-5	1895?	do	105	105	80	52	do	100.00		Irrigation	†10	
644	do	do	A-5	1895?	do	105	105	80	53	do	100.00		do	†10	
645	do	do	A-5	1895?	do	104	104	80	52	do	100.00		do	†10	
646	Mr. Forthman	do	A-5		Bored, 8-inch	107	107	80	52	Artesian, wind			Domestic	Small.	
647	do	do	A-5		Bored, 7-inch	109	109	85	52	Artesian			Irrigation		
648	do	do	A-4,5		Bored, 9½-inch	109	109	85	51	do			do		
649	do	do	A-4,5		do	108	108	82	52	do			do		
650	do	do	A-4,5		do	107	107	80	48				do		
651	Philip Valenzude	do	A-4	1887		110	107	85	50	Hand	100.00		Domestic		
652	Tajantaschool district	do	A-4	1888?	Bored, 7-inch	113	113	85	49	Artesian	100.00		do	Small.	
653	F. M. Anderson	do	A-4	1890	do	113	113	84	51	Wind	100.00		do		
654	do	do	A-4	1891	do	112	110	450	33				Irrigation		
655	do	do	A-4	1890	do	116	114	84	45						

Wells in the Downey quadrangle—Continued.

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						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
656	Thos. Duggan	San Antonio	A-4	1890?	Bored, 4-inch	115	115	84	50				Domestic; irrigation.	
657	C. D. Barklew	do	A-5		do	111	110	80	44	Wind			Domestic	
658	Pacific Electric R. R. Co.	do	A-4		Bored, 7-inch	112	112	85	51	Wind, electricity.			do	
659	Geo. J. Ley	do	A-4	1902	Hydraulic, 2-inch	113	112	90	51	Hand	$49.00		do	
660	do	do	A 4	1883	Bored, 5-inch	115	113	74	51	do			do	
661	do	do	A 4	1883	Bored, 6-inch	115	113	74		do			Stock; irrigation	
662	Mrs. Lena Diller	do	A 5	1897	Bored, 7-inch	109	109	72	51	Gas			Irrigation	
663	Mr. Mackley	do	A 4.5	1895?	Bored, 5-inch	112	111	85	51	Hand			Domestic	
664	F. E. Ramsaur	do	A 5	1887	Bored, 7 inch	106	106	72	48	Artesian			Stock	
665	do	do	A 5	1900	Bored, 10-inch	106	106	69	43	do			do	Small.
666	do	do	A 4	1888?	Bored, 7-inch	117	115	78	51	Hand			Domestic	
667	W. F. Ruoff	do	A 4	1887	do	118	116	84	47	Wind	110.00	$75.00	Irrigation; domestic.	
668	do	do	A 4	1893	do	117	117	72	51	Artesian	85.00		Irrigation	Small.
669	Chas. Lash	do	A 4	1888	do	116	114	150	51	Wind		100.00	Not used	
670	do	do	A-4	1882	do	115	114	86	50				do	
671	David Elcout	do	A 4	1896	do	122	117	90	49		100.00		Irrigation	
672	Jacob Bosshard	do	A-4	1898	do	127	121	160			200.00		Not used	
673	Mrs. E. Crane	do	A-4	1889	Bored, 4-inch	127	120	105		Hand			Domestic	
674	Mr. Stege	do	A-4		Bored, 7-inch	125	119	90	49	do	100.00		do	
675	J. F. Donohue	do	A-4	1884	do	124	118	100	49	Wind			do	
676	S. H. Minor	do	A-4	1890	Bored, 3-inch	125	120	95	46	do	80.00	150.00	Irrigation; domestic.	

677	.....do.....	.....do.....	A-4.....	1890	Bored, 7-inch.....	127	123	105	53	Hand.....	125.00	.....	Stock.....	.....
678	H. F. Starks.....	.....do.....	A-4.....	1898	.....do.....	122	117	123	49	Wind.....	130.00	225.00	Domestic; irrigation.	.....
679	.....do.....	.....do.....	A-4.....	1898	Bored, 10-inch....	123	118	118	49	.....	150.00	.....	Not used.....	.....
680	.....do.....	.....do.....	A-4.....	1888	Bored, 7-inch.....	121	117	100	49	.....	150.00	.....	Stock.....	.....
681	.....do.....	.....do.....	A-4.....	1888	.....do.....	118	115	100	49	.....	150.00	.....	Not used.....	.....
682	Mr. Gilmore.....	.....do.....	A-4.....	1887?	.....do.....	125	120	105	52	Hand.....	.....	.....	Domestic.....	.....
683	H. D. Merrill.....	.....do.....	A-4.....	1883	.....do.....	130	121	130	52	.....do.....	140.00	.....	.....do.....	.....
684	.....do.....	.....do.....	A-4.....	1903	.....do.....	129	120	70	45	.....	100.00	.....	Not used.....	.....
685	A. E. Putney.....	.....do.....	A-3, 4...	1887	.....do.....	132	122	135	46	Compressed air.	200.00	1,000.00	Irrigation.....	70
686	J. W. Kent.....	.....do.....	A-4.....	.....	.....do.....	131	121	120	53	Gas.....	175.00	1,000.00	Irrigation; domestic.	70
687	Mrs. Emma Crane.....	.....do.....	A-4.....	1888	.....do.....	130	121	120	75	.....do.....	.....	1,000.00	Irrigation.....	.....
688	Mr. Joseph Burkhart.	.....do.....	A-3.....	.....	Bored, 10-inch....	134	121	165	33	.....	.....	.....	Not used.....	.....
689	.....do.....	.....do.....	A-3.....	.....	Bored, 7-inch.....	133	121	.....	52	Wind.....	.....	60.00	Stock.....	.....
690	.....do.....	.....do.....	A-3.....	.....	.....do.....	131	122	85	28	.....	.....	.....	Not used.....	.....
691	.....do.....	.....do.....	A-3.....	.....	.....do.....	129	121	.....	73	.....	.....	.....	.....do.....	.....
692	.....do.....	.....do.....	A-3.....	.....	.....do.....	131	121	120	25	.....	.....	.....	.....do.....	.....
693	F. X. Eberle.....	.....do.....	A-4.....	1885	.....do.....	126	120	130	51	Hand.....	.....	.....	Domestic.....	.....
694	L. M. Russell.....	.....do.....	A-3.....	1882	.....do.....	137	127	109	53	.....do.....	100.00	.....	.....do.....	.....
695	M. Inglis.....	.....do.....	A-3.....	1902	Bored, 6-inch.....	138	124	106	....	Wind.....	120.00	233.00	Domestic; irrigation.	.....
696	A. Inglis.....	.....do.....	A-3.....	1882	Bored, 7-inch.....	139	124	109	54	.....do.....	125.00	200.00	Domestic.....	.....
697	G. A. Nadeau.....	.....do.....	A-3.....	1873	.....do.....	139	122	150	52	.....	200.00	.....	Not used.....	.....
698	.....do.....	.....do.....	A-3.....	1875	.....do.....	138	132	150	....	Wind.....	200.00	150.00	Stock.....	.....
699	.....do.....	.....do.....	A-3.....	1875	.....do.....	144	125	155	....	.....	200.00	.....	Not used.....	.....
700	Mrs. G. Rutan.....	.....do.....	A-3.....	1902	.....do.....	145	126	160	53	Wind.....	200.00	150.00	Domestic.....	.....
701	Southern Pacific Co...	.....do.....	A-3.....	1885	Bored, 6-inch.....	142	124	149	52	Gas.....	150.00	500.00	Engines	11
702	Mrs. E. A. Stout.....	.....do.....	A-3.....	.....	Bored, 7-inch.....	141	124	127	49	Hand.....	.....	.....	Domestic.....	.....
703	Fred Shores.....	.....do.....	A-3.....	1903	.....do.....	138	124	85	39	.....do.....	105.00	.....	.....do.....	.....
704	S. F. Estell.....	.....do.....	A-3.....	1891	Bored, 2-inch.....	141	125	90	51	.....do.....	45.00	.....	Irrigation; domestic.	.....
705	Robert Thaxter.....	.....do.....	A-3.....	1897	Bored, 7-inch.....	147	125	95	63	Wind.....	125.00	200.00	Domestic.....	.....
706	A. Aylmore.....	.....do.....	A-2.....	1897?	.....do.....	154	128	103	61	.....do.....	.....	200.00	.....do.....	.....
707	E. F. Smith & Co.....	.....do.....	A-2.....	1898?	Bored, 2-inch.....	153	.....	.....	.....	.....do.....	.....	200.00	Not used.....	.....
708	G. A. Blakeslee.....	.....do.....	A-2.....	1885	Bored, 7-inch.....	158	128	98	68	Hand.....	120.00	5.00	Domestic.....	.....

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
709	Z. L. Parmlee	San Antonio	A-2		Bored, 7-inch	161	133	75	67	Wind		$200.00	Domestic	
710	I. H. Bryson	do	A 2	1897	do	167	130	92	46	do	$125.00	200.00	do	
711	Z. S. Spalding	do	A-2	1899	Bored, 10-inch	162	131	100	91	do	125.00	200.00	do	
712	Joe Dutcher	do	A 2		Bored, 2-inch	165	132?	75	85	do	40.00	200.00	do	
713	Mr. C. Dutcher	do	A 2	1902	Bored, 7-inch	167	132	100	75	do	120.00	200.00	do	
714	do	do	A 2	1888	do	168		60	70	do	60.00	200.00	Stock	
715	Chas. Porter	do	A 2	1888	do	169	136	61	78	Hand	60.00		Domestic	
716	Ed Trapp	do	A 2	1901	do	170		75	68	Wind	70.00	350.00	do	
717	F. Ahrens	do	A-2	1902	Bored, 1½-inch	173	133	60		do	20.00	180.00	do	
718	do	do	A 1	1900	Driven, 2-inch	175		63	66	Hand	20.00		do	
719	Nadeau Town Site Improvement Co.	Los Angeles city	A 1		Bored, 7-inch	179		100	49	Wind		225.00	do	
720	Los Angeles Land Co.	do	B 7		do	185	136	100?	51	Hand			do	
721	Mrs. Thompson	do	A-1	1890?	do	175			70	Wind		250.00	do	
722	H. Cornelson	do	A-1	1900	Driven, 2-inch	181	151?	70	62	Hand	40.00		do	
723	Andrew Daneri	do	A-1	1899	Bored, 7-inch	188	143	75	56	Wind	75.00	200.00	do	
724	J. Gibbs	do	A-1	1891	do	190	142	66	52	Hand	90.00		do	
725	R. S. Smith	do	A-1		Bored, 6-inch	188	140	63	53	Wind	75.00	225.00	do	
726	I. Gibbs	do	A 1	1881	Bored, 7-inch	191	142?	65	53	do	80.00	250.00	do	
727	J. T. Gitchell	do	A-1	1892	do	194	140	63	52	do	85.00	145.00	do	
728	P. W. Sams	do	A-1	1888	Bored, 6-inch	196	137	65	53	Wind, horsepower	80.00	200.00	do	
729	J. W. Simpson	do	A-1	1902	Bored, 7-inch	195	130	85	52	Wind	200.00	200.00	Domestic; irrigation	

730	H. A. Moore	do	A-1	1884	do	192	135	68	52	do			Domestic	
731	John W. Mills	do	A-1	1900	do	193		70	50	Gas	25.00	125.00	Domestic; irrigation.	
732	Mrs. M. J. Brewster	do	A-1	1899	do	196	154	68	52	Hand	75.00		Domestic	
733	Mrs. J. L. Adams	do	A-1		do	196			53	Wind		150.00	do	
734	S. S. Harper	do	A-1	1903	do	191	136	91	48	Gas	110.00	150.00	do	
735	Pacific Electric R. R. Co.	do	A-1	1893	do	194	136	90	52	Wind	110.00	200.00	do	
736	Mr. Carasosa	do	A-1		Bored, 3-inch	189			51	do			do	
737	Chas. M. More	do	A-1	1899	Bored, 9-inch	193	141	192	47	Compressed air	700.00		Not used	
738	Moore Bros	do	B 1	1900	Bored, 12-inch	193	138	226	33	do	700.00		Irrigation	55
739	do	San Antonio	B 1	1901	do	193	138	226	33	do	700.00		do	55
740	Mr. Anderson	Los Angeles city	A-1	1898?	Bored, 7-inch	189	136	75	46	Wind	75.00	150.00	Domestic	
741	Moore Bros	San Antonio	B-1	1902	do	186	135	74	41	Hand	75.00		do	
742	Maria Alvaris	do	B-1	1891	do	192	137	62	43	do	80.00		do	
743	E. O. McClure	Los Angeles city	A-1	1898	Bored, 10-inch	192	143	440	41	Wind	960.00	150.00	do	
744	John Moore	do	A-1	1901	Bored, 7-inch	191	140	78	44	Gas	200.00	315.00	Stock; domestic	1
745	J. Furlong	do	A-1	1900	Bored, 6-inch	183	133	60	41	Hand			Domestic	
746	do	do	A-1	1899	Bored, 7-inch	183	133	70	45	do	75.00		Not used	
747	Furlong Bros	do	A-1	1901	do	186	126?	68	45	Wind	80.00	85.00	Domestic	
748	E. P. Merritt	do	A-1	1885?	do	186	134	70	40	do	80.00	200.00	do	
749	J. G. White	do	A-1	1883	do	182	132?	70	45	do	75.00	175.00	do	
750	N. J. White	do	A-1	1902	do	182	133	62	42	Hand, gas	120.00		Domestic; irrigation.	
751	Pacific Electric R. R. Co.	do	A-1	1892	do	182	133	65	42	Wind	75.00	150.00	Domestic	
752	E. M. Landon	San Antonio	A-2	1888?	do	179		90		do	100.00		do	
753	Mr. Peralta	do	A-1	1901	do	180	135	64	41	Hand	80.00		do	
754	Caytano C. Quijada	do	A-1	1901	do	180	135	74	42	Wind	100.00		do	
755	Nellie E. Prescott	do	A-2	1901	do	178	135	83	40	do	85.00	235.00	do	
756	Mrs. D. L. Page	do	A-1	1900	do	179	133	85	36	do			Domestic; irrigation.	
757	John T. Holly	do	A-2	1893	Bored, 4-inch	178		86	41	Hand	100.00		Domestic	
758	Mr. Reed	do	A-2	1895	Bored, 7-inch	178		75?	40	do	80.00		do	
759	J. C. Higgins	do	A-2	1899	do	177		80	43	Wind	100.00	100.00		
760	Amer. Agr. Chem. Co.	do	A-2	1898	Bored, 10-inch	176	134	90	35	Steam			Factory	
761	E. G. Underher	do	A-2	1883	Bored, 7-inch	173	133	85?	53	Hand			Domestic	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
762	John B. Morrison	San Antonio	A-2	1886	Bored, 7-inch	173	135	89	40	Wind	$75.00		Domestic	
763	Mrs. E. S. Morrison	do	A-2	1884	do	171	134	88	41	do	80.00	$125.00	do	
764	Mrs. Paris	do	A-2	1897	do	160	134	90	38	do	90.00		do	
765	Geo. Jones	do	A-2	1884	do	166	131	120	38	do	125.00	150.00	do	
766	John Booth	do	A-2	1891	do	165	130	60?	40	do			do	
767	Mrs. O. J. Nichols	do	A-2	1887	do	166	132	60	48	Hand	70.00	2.50	do	
768	Miss B. Morrison	do	A-2	1884	do	165	132	109	42	Wind	140.00		do	
769	Mr. Ingalls	do	A-2	1888?	do	162	127	63	42	Hand			do	
770	M. J. Innes	do	A-2	1900	do	159	128	100	41	Wind	100.00	180.00	Domestic; irrigation.	
771	Mrs. Marie Kramer	do	A-2	1890?	do	158	128	83	42	do			Domestic	
772	H. B. Blakeley	do		1883	do	159	129	69	42	do	*315.00		do	
773	H. M. Vance	do	A-2	1883	Bored, 4-inch	158	128	69	47	do	65.00	180.00	Domestic; irrigation.	
774	do	do	A-2	1897	Bored, 7-inch	159	128	68	46	do	70.00	175.00	Irrigation	
775	Methodist Episcopal parsonage.	do	A-2	1895	do	159	128	70	105	Hand			Domestic	
776	J. F. Ahlstrom	do	A-2	1888	do	160	127	70?	53	Wind			do	
777	Mrs. Blakesley	do	A-2		do	157	128	75?	....	Hand			do	
778	Florence school district.	do	A-2	1883	do	157	127	75	53	Wind	75.00	200.00	do	
779	F. E. Cleland	do	A-2	1883	do	157	127	78	56	do	80.00	200.00	do	
780	Alfred Lane	do	A-2	1893	do	157	127	84	47	Gas			Domestic; irrigation.	35
781	Mrs. Clark	do	A-2	1890	do	157	127	85?	42	Wind		150.00	Domestic	

782	Oliver Foster	do	A-2	1888?	do	160	129	80	42	do	80.00	200.00	do		
783	Mrs. B. A. Clark	do	B-2	1903	do	160	129	95	38	do	95.00	70.00	Domestic; irrigation.		
784	J. Cosgrove	do	A-2	1902	Bored, 5-inch	157	122?	76	43	Gas	65.00		Domestic		
785	Mr. Bixby	do	A 3	1888?	Bored, 7-inch	153	128	52	52	Wind			do		
786	Edward Alvares	do	A-3	1902	do	149	127	85		do	85.00	70.00	do		
787	E. Reiman	do	A-3		Driven, 2-inch	148	126	80		do			do		
788	R. Nadeau	do	A-2	1900	Bored, 10-inch	155	124	87		Gas	310.00	1,500.00	Irrigation		60
789	do	do	A 2	1883	Bored, 7-inch	155	116	80	49	Wind	85.00		Domestic		
790	Mrs. R. B. Durfee	do	A-3	1885	do	147	129	500	33	do			do		
791	Mrs. A. A. Lipsey	do	A-3	1894	Bored, 2-inch	144	128	92	47	do	45.00	125.00	do		
792	Mrs. Cox	do	A-2		do	145		60	65	Hand	30.00		Stock		
793	W. S. Barlowe	do	B-3	1902	Bored, 5-inch	143	126	30		do			do		
794	Mrs. F. Winters	do	B-3	1901	Bored, 7-inch	143	129	81	49	do	85.00		Domestic		
796	A. Huston	do	B-3	1902	Bored, 5-inch	143	130	25	70	do	25.00		do		
797	J. Marsh	do		1899	Bored, 2-inch	144		75	48	do			do		
798	S. C. Darby	do	B-3	1891	Driven, 2-inch	142		90	52	do	45.00		do		
799	F. M. Fulston	do	B-2	1900	Bored, 7-inch	167		90	39	Wind		200.00	Domestic; irrigation.		
800	W. M. Patterson	do	A, B-2	1897	do	168	133	90	39	do	100.00	200.00	do		
801	Michael Cudahy	do	B-2	1899	Bored, 12-inch	156	122	391	35	Compressed air	1,000.00	2,000.00	Irrigation		†60
802	do	do	B-2	1899	do	156	122	407	35	do	1,000.00	2,000.00	do		†60
803	do	do	B-2	1899	do	156	122	431	42	do	1,000.00	2,000.00	do		†60
804	do	do	B-2	1900	do	155	121	376	40	do	1,000.00	2,000.00	do		†60
805	do	do	B-2	1900	do	155	121	116		do	1,000.00	2,000.00	do		†60
806	do	do	B-2	1900	do	155	121	379	40	do	1,000.00	2,000.00	do		†60
807	do	do	B-2	1900	do	155	121	376	42	do	1,000.00	2,000.00	do		†60
808	do	do	B, C-4		Bored, 4-inch	131	131	80	40	Wind			Stock		
809	do	do	C-3	1901	Bored, 8-inch	132	117	165		do	231.00		do		
810	do	do	D-4	1883?	do	124	114	150	35	do			do		
811	do	do	D-3	1883	Bored, 7-inch	131	120	60	36	do			Domestic		
812	do	do	D-3, 4	1883	do	123	114	90	36	do			Stock		
813	do	do	D-3	1883	do	129		60	31	do			Domestic		
814	do	do	E-3		do	128	122	80	32	do			Stock		
815	do	do	C-3		do	159	130	80	38	do			do		
816	D. Cunningham	do	B-2		do	158	129	75	35	do	75.00		Domestic		

Wells in the Downey quadrangle—Continued.

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						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
817	Michael Cudahy	San Antonio	B-2	1899	Bored			115	38	Compressed air.	$250.00		Boilers	
818	D. Cunningham	do	B-2	1902	Bored, 12-inch	109	133	190	35	do	500.00		Irrigation	50
819	H. W. Benson	do	C-2	1884	Bored, 2-inch	156			72	Hand		$2.50	Domestic	
820	A. F. Fishring	do	B-2	1903	Bored, 7-inch	175	130	89		do	108.00		do	
821	Mr. Nutt	do	B-2	1897	Bored, 11-inch	170	130	280		Gas			Irrigation	†120
822	G. H. Stevens	do	B-2	1902	Bored, 7-inch	177	132	85	33	Wind	90.00	250.00	Domestic	
823	E. V. Baker	do	B-1		do			58					Not used	
824	Mrs. Baker	do	C-1	1902	do	173	150	60	53	Hand	60.00		Domestic	
825	G. W. Brookins	do	C-1	1902	do	177	147	60	73	Wind	60.00	150.00	do	
826	Marian Dodson	do	B-1	1899	do	175	145?	95	52	Hand	100.00		do	
827	Mr. Buchanan	do	B-1	1900	Bored, 4-inch	176		120		Wind			do	
828	W. W. Shea	do	B, C-1		Bored, 7-inch	182	133			do			do	
829	Alfred Lemon	do	B-1	1894	do	182	141	77	54	do	75.00	200.00	do	
830	J. H. Chapman	do	B-1	1895	do	178	128	115	41	do	115.00		do	
831	J. W. Batcheller	do	C-1	1883	do	184	138	95	37	do	100.00		do	
832	San Antonio school district.	do	C-1	1899	do			225	35	Hand			do	
833	F. P. Walker	do	C-1	1878	do	185	139	90		Wind	90.00		do	
834	E. J. Polkinhorn	do	C-1	1902	do	181	139	105	39	do	110.00	200.00	do	
835	Mr. Russell	do	C-1	1880	do	179	139	80		do			Domestic; stock	
836	Wm. Angel	do	C-1	1901	do	180	140	74	30	Hand			Domestic	
837	W. J. Barr	do	C-1	1902	do	183	143?	108	45	do	160.00		do	
838	J. F. Francis	San Pedro	A-11		Dug, 3 by 3 foot	50	41	14		Wind		75.00	Stock	
839	Jesus Cruz	do	B-11	1903	Bored, 10-inch	49	42	143	31	do			Domestic	

840	Mr. Cheriotto	do	B-12	1903	do	33	26	160	.....	Gas?	300.00	.....	Irrigation	.....	
841	Mr. Shurota	do	B-12	1883?	Bored, 6-inch	33	26	150?	45	Hand	.....	.....	Domestic	.....	
842	M. Mindrup	do	B-11	1900	Bored, 2-inch	44	.....	101	.....	do	50.00	.....	Not used	.....	
843	G. Delamo	do	C-11	1899	Bored, 12-inch	43	43	940	25	Artesian	200.00	.....	Irrigation	.....	35
844	do	do	B-11	1900	Bored, 2-inch	43	33?	94	37	Wind	50.00	150.00	Domestic	.....	
845	R. M. Bobst	do	B-11	1901	do	41	.....	106	51	Hand	50.00	.....	do	.....	
846	J. Malcom	do	B-11	.....	Bored, 7-inch	42	34	185	37	Wind	.....	.....	do	.....	
847	Mrs. Carson	do	A-12	.....	Driven, 2-inch	30	24	95	37	Hand	.....	.....	do	.....	
848	S. Todd	do	A-13	.....	Bored, 7-inch	25	20	275	37	do	.....	.....	do	.....	
849	Mr. Bangel	do	B-13	1899	Driven, 2-inch	31	26	96	.....	do	50.00	.....	do	.....	
850	Mrs. Chas. Guyer	do	B-13	1898	do	32	26	80	41	Wind	.....	.....	Domestic; stock	.....	
851	Mrs. Carson	do	C-12	1898	Bored, 10-inch	32	27	140	35	Hand	.....	.....	Domestic	.....	
852	do	do	C-12	1898	do	33	27	140	39	Gas	.....	.....	Not used	.....	
853	Miss Y. Dominguez	do	B, C-12	1898	do	35	26	140	37	do	.....	.....	do	.....	
854	J. F. Francis	do	C-11, 12	1900	Driven, 2-inch	35	26	80	38	Wind	.....	.....	Domestic	.....	
855	G. Dominguez	do	B-11	1903	Bored, 2-inch	32	25	106	40	Hand	.....	.....	do	.....	
856	J. F. Francis	do	C-11	1898	Bored, 10-inch	36	28	110	.....	Gas	.....	.....	Not used	.....	
857	Schoolhouse	do	B-12	1895	Bored, 2-inch	32	24	90	.....	Hand	.....	.....	Domestic	.....	
858	O. E. Elftman	do	B-12	1902	Bored, 12-inch	33	25	535	37	Gas	1,100.00	.....	Irrigation	.....	120
859	do	do	B-12	1895	Bored, 10-inch	33	25	143	41	Wind	275.00	.....	Domestic	.....	
860	Geo. Silvera	do	B-11, 12	1902	Bored, 2-inch	32	25	106	47	Hand	53.00	.....	do	.....	
861	O. E. Elftman	do	B-12	1902	Bored, 12-inch	31	24	50	39	Gas	275.00	.....	Irrigation	.....	120
862	do	do	B-12	1895	Bored, 2-inch	31	24	100	40	Hand	50.00	.....	Stock	.....	
863	M. E. Tolle	do	C-13	1890	Bored, 4-inch	25	...	86	44	.....	.....	.....	Domestic	.....	
864	G. H. Bixby	Los Cerritos	C-13	1901	Bored, 7-inch	50	13	400	27	Gas	.....	150.00	Domestic; stock	.....	
865	J. M. Carson	San Pedro	C-12	1900	Bored, 2-inch	28	19	137	.....	do	70.00	.....	Domestic	.....	
866	do	do	B-13	1897	do	25	...	40	37	Wind	70.00	150.00	Stock	.....	
867	do	do	B-13	1900	Bored, 10-inch	25	18	225	35	Gas	500.00	.....	Irrigation	.....	100
868	L. E. Torrey	do	B-13	1901	Bored, 2-inch	25	15?	140	37	Wind	70.00	150.00	Domestic	.....	
869	S. D. Wilson	do	B-13	1899	do	25	19	100	.....	do	50.00	.....	do	.....	
870	Milton Brown	do	C-13	1898	Dug, 3 by 3 foot	227	16	18	73	Hand	.....	.....	do	.....	
871	W. True Molton	do	C-13	.....	Bored, 7-inch	24	16	108	57	do	.....	.....	do	.....	
872	Mr. Mayberry	do	C-13	.....	do	23	16	100	59	Wind	.....	.....	do	.....	
873	A. J. Green	do	C-13, 14	1883	do	23	16	90	.....	do	.....	.....	do	.....	
874	Mr. Kincaid	do	C-13	1883?	do	23	16	10	200+	do	.....	.....	do	.....	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
875	A. Allison	San Pedro	C-13	1888	Dug, 3 by 3 foot	22	17	8	200+	Hand			Domestic	
876	Mrs. Francis MacDonald.	do	C-14	1885	do			11		do			do	
877	B. A. Mathewson	do	D-14	1902	do			9	200+	do			do	
878	P. J. Watson	do	B-14	1897	Bored, 4-inch	25	20	340	49	Wind	$300.00		Stock	
879	do	do	A-13	1900	Bored, 2-inch	23		450	30	Artesian			do	Small.
880	do	do	A-13	1894	Bored, 7-inch	25	3	154	29	Wind	250.00		Domestic; irrigation.	
881	San Pedro Lumber Co.	do	A-16	1903	Dug, 3 by 3 foot	23	12	15	55				Sawmill	
882	San Pedro Salt Co	do	B-16	1902	Bored, 7-inch	4	7	158	56	Artesian	200.00		Boiler	
883	G. H. Bixby	do	B-15		do	15	12	86	37	Wind			Stock; domestic	
884	L. Byrnes	do	B-15	1893	Bored, 4-inch	11	10	98	37	Artesian, wind			Stock	Small.
885	John Ena	do	B-15	1898	Bored, 12-inch	11	13	784	32	Artesian			do	Small.
886	John Scott	do	B-15	1880	Bored, 7-inch	11	10	180		do	200.00		do	
887	John Ena	do	C-15	1885?	do	15	14		39	do			do	Small.
888	Geo. Cordell	do	C-15	1890	do	11		100	38	Hand	100.00		Domestic	
889	Geo. Loper	do	B-15	1901	Bored, 4-inch	14		100	38	do	75.00		do	
890	Ira Roberts	do	B-14		Driven, 2-inch	15	12	85		do	45.00	$2.50	do	
891	W. Martin	do	B-14	1888	Bored, 4-inch	16	13	100	38	Wind	85.00		do	
892	F. W. Gilson	do	B-14	1888?	Bored, 7-inch	16	11	100	31	Hand	100.00		do	
893	W. H. Westover	do	B-14	1888	Bored, 6-inch	15	11	100		Wind			do	
894	E. Loper	do	B-14	1893	Bored, 4-inch	17	12	100	37	do	75.00	135.00	do	
895	M. Pike	do	B-14	1888?	Bored, 7-inch	18	12	95	35	do	95.00		do	
896	Fred Maskew	do	B-14	1896	Bored, 2-inch	18	12	90	37	Hand	35.00		do	

897	Mrs. E. M. Wiley	do	B-14	1897	Bored, 4-inch	18	12	85	37	Wind	70.00	150.00	do	
898	P. J. Watson	do	A-14	1885	Dug, 4 by 4 foot	25	12	21	70	do			do	
899	Mrs. Lily Watson	do	A-14		Bored, 7-inch	28	9	162	30	do			do	
900	Mrs. Emery	do	B-14	1896	Bored, 2-inch	18	11	85		Hand			do	
901	Mrs. Guyer	do	B-12	1899	Bored, 10-inch	31	24	149		Gas	200.00		Irrigation	125
902	G. N. Wines	do	B-13		Bored, 2-inch	20	19?	170	33	Wind			Domestic	
903	R. H. Martin	do	B, C-14	1892	Bored, 6-inch	17	11	116		do	115.00		do	
904	Cerritos school district	do	C-14	1883	Bored, 2-inch	17	11	90		Hand	45.00		do	
905	S. O. Davis	do	C-14	1880	Bored, 6-inch	17	12	120	62	Wind			do	
906	do	do	C-14	1887	do	14	9	110					Not used	
907	Mrs. Graydon	do	C-14	1891	Bored, 4-inch	14	9	100		Wind			Domestic	
908	John Leuer	do	C-15	1885	do	13	12	92		Hand			do	
909	E. S. Rosenberg	do	C-15	1895	Bored, 6-inch	15	11	105	39	Wind			Domestic; irrigation	
910	C. A. Westgate	do	C-14	1885	Bored, 7-inch	14	12	100	60	do			Domestic	
911	Henry Schief	do	C-14	1898	Bored, 2-inch	13	11	94	60	Hand	35.00		do	
912	Geo. Cordell	do	C-15	1888	Bored, 7-inch	13	12	125		Wind			do	
913	Mrs. B. F. Browers	Los Cerritos	D-15			23	11	70	200+	do			do	
914	Frank Pit	do	C-15		Bored, 2-inch	20		80?	70	do			do	
915	H. F. Mallernee	do	E-10	1897	do	53	51	317			125.00		Not used	
916	Geo. H. Bixby	do	E-11	1898	Bored, 10-inch	51	51	672	20	Artesian			Irrigation	190
917	do	do	E-11		Bored, 2-inch	52	52	350?	20	do	300.00		Domestic; stock	
918	do	do	E-11		Bored, 7-inch	52	52	350	23	do			Stock	
919	do	do	D-11	1897	Bored, 10-inch	48		500+	23	do			do	1
920	do	do	D-11		Bored, 7-inch	45	45	310?	23	do			do	2
921	do	do	D-11		do	45		350?	25	do			Irrigation	4
922	do	do	D-12	1869	do	80	48	350?	22	Wind			Domestic	
923	do	do	D-12	1898	Bored, 10-inch	105	50	500	22	Gas			do	
924	do	do	D-13		Bored, 4-inch	100		400?	22	Wind			do	
925	R. F. De Garmo	do	D-15	1890?	Dug, 3 by 3 foot	25	11	21	161	do			do	
926	G. W. Olsen	do	D-14	1903	do	24	11	15	172	Hand			do	
927	R. W. Patterson	do	D-14	1894	Bored, 7-inch	59	4	425?	37	Wind	1,000.00		Domestic; irrigation	
928	A. M. Neece	do	D-14	1891	do	50	10	240	39	do	500.00		Domestic	
929	J. Andrews	do	D-14	1890	do	45	31	120	80	do	*503.00		Domestic; irrigation	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
930	J. B. Rain	Los Cerritos	E-14	1888	Bored, 4-inch	73	21	264					Not used	
931	Mr. Wardlowe	do	E 14		Bored, 7-inch	63	21		36	Wind			Domestic; irrigation.	
932	Z. T. Nelson	do	E-14		do	100	9	155		do			do	
933	G. A. Lindsay	do	D 16	1897	Bored, 4-inch	37	12	72	27	do			Irrigation	
934	Seaside Water Co	do	E-12		Bored, 14-inch	61	61	730	21	Artesian			Domestic	
935	do	do	E-12		Bored, 14, 12-inch	61	61	700		do				
936	do	do	E 12	1900	Bored, 12-inch	61	61	767		do			Domestic	
937	do	do	E 12		Bored, 10-inch	71	71	400	19				Not used	
938	do	do	E 12		Bored, 7-inch	61	61	400					Irrigation	
939	do	do	E 13	1901	Bored, 14-inch	62	62	684	19	Artesian			Domestic	†100
940	do	do	E 13	1899	Bored, 8-inch	57	57	707	19	do			do	
941	Geo. H. Bixby	do	E-13	1888	Bored, 7-inch	62	62	250	21	do			Not used	
942	do	do	E-13	1902	Bored, 2-inch	62		450	22	do			Domestic	Small.
943	Seaside Water Co	do	E 13		do	60	60	350	21	do			Not used	
944	J. Ross Clark	do	E-12	1900	Bored, 12-inch	61	61	838	23	do	$2,500.00		Irrigation	†95
945	W. A. & J. R. Clark	do	E-12	1893	Bored, 10-inch	69	69	350					Domestic	
946	do	do	E-12	1893	Bored, 8-inch	69	60	350		Artesian			Stock	
947	do	do	F-12	1901	Bored, 4-inch	57	57	400	17?	do	280.00		Domestic	12
948	do	do	F-12	1901	do	52	52	400		do	280.00		Stock	17
949	do	do	F-12	1901	do	60	60	400	17?	do	280.00		do	12
950	Seaside Water Co	do	E-13		Bored, 2-inch	53	53			do			do	3
951	do	do	E-13		do	53	53			do			Not used	
952	G. R. Wilson	do	E 10	1899	do	58	58	420		do			Irrigation; stock	

953	.....do.....	.....do.....	E-10....	1899	.....do.....	57	57	410	25	.....do.....	250.00	.....	Domestic.....	.....	
954	W. H. McKelvey.....	.....do.....	F-10....	1899	.....do.....	57	57	410	23	.....do.....	.....	.....	Stock.....	†3	
955	Geo. H. Bixby.....	.....do.....	F-10....	1902	.....do.....	57	57	400?	22	.....do.....	.....	.....	Not used.....	.....	
956	D. B. Gemmill.....	.....do.....	F 10....	1900	Bored, 7-inch.....	56	54	100?	35	Gas.....	.....	.....	Irrigation.....	.....	
957	.....do.....	.....do.....	F-10....	1900	Bored, 2-inch.....	56	54?	100	25	Hand.....	40.00	.....	Domestic.....	.....	
958	G. F. Sparks.....	.....do.....	G-11....	1876?	Bored, 4-inch.....	52	52	400?	25	Artesian.....	.....	.....	Domestic; stock.	5	
959	J. R. Clark.....	.....do.....	H 11....	1902	.....do.....	51	51	373	.....	.....do.....	225.00	.....	Irrigation.....	15	
960	.....do.....	.....do.....	H-11....	1897	Bored, 2-inch.....	51	51	400	23	.....do.....	200.00	.....	Domestic.....	.....	
961	J. Ross Clark.....	.....do.....	H-11....	1902	Hydraulic, 4-inch.	52	52	403	23	.....do.....	.....	.....	Irrigation.....	15	
962	.....do.....	.....do.....	G-11....	1902	Bored, 4-inch.....	52	52	420	.....	.....do.....	225.00	.....	.....do.....	27	
963	.....do.....	.....do.....	H-11....	1902	.....do.....	51	51	398	23	.....do.....	225.00	.....	.....do.....	.....	
964	.....do.....	.....do.....	H-11....	1900	Bored, 10-inch....	47	47	700	22	.....do.....	1,800.00	.....	.....do.....	39	
965	.....do.....	.....do.....	I-1.....	1891	Bored, 2-inch.....	43	43	400?	23	.....do.....	.....	.....	Domestic.....	Small.	
966	.....do.....	.....do.....	I-12....	1895	.....do.....	35	35	130	30	.....do.....	.....	.....	.....do.....	Small.	
967	.....do.....	.....do.....	I 12....	1890?	.....do.....	33	33	140	28	.....do.....	60.00	.....	.....do.....	.....	
968	C. W. Coseboon.....	.....do.....	E-14....	1885	Bored, 7-inch.....	150	98	180	25	Wind.....	.....	$70.00	.....do.....	.....	
969	Citizens' Water, Light and Power Co.	Los Alamitos....	F-14....	1903	Bored, 12-inch....	43	43	420	19	Artesian.....	1,000.00	.....	.....do.....	33	
970	.....do.....	.....do.....	F-14....	1903	.....do.....	41	41	460	.....	.....do.....	1,200.00	.....	Not used.....	†150	
971	.....do.....	.....do.....	F-14....	.....	.....do.....	46	46	713	.....	.....do.....	.....	.....	.....do.....	.....	
972	Geo. H. Bixby.....	.....do.....	F-14....	1883	Bored, 7-inch.....	46	46	450?	19	.....do.....	.....	.....	Stock.....	†5	
973	Bixby Land Co.....	.....do.....	F-14....	1901	Bored, 12-inch....	45	45	619	.....	.....do.....	.....	.....	Irrigation.....	61	
974	.....do.....	.....do.....	F-14....	1902	.....do.....	46	46	400?	20	.....do.....	.....	.....	Domestic.....	.....	
975	.....do.....	.....do.....	F-13....	1902	Bored 9½-inch....	36	36	427	20	.....do.....	.....	.....	Irrigation.....	160	
976	J. Ross Clark.....	Los Cerritos.....	G-12, 13.	1890	Bored, 4-inch.....	28	28	412?	19	Artesian, hand..	280.00	.....	Domestic.....	Small.	
977	.....do.....	.....do.....	G-12....	1902	Bored, 2-inch.....	38	38	74	21	Artesian.....	35.00	.....	.....do.....	.....	
978	.....do.....	.....do.....	G-12....	1897	Bored, 7-inch.....	38	38	400?	21	.....do.....	.....	.....	.....do.....	.....	
979	G. R. Clark.....	.....do.....	H-12....	1898	Bored, 2-inch.....	.....	.....	325	19	.....do.....	150.00	.....	.....do.....	.....	
980	.....do.....	.....do.....	H-12....	1901	Bored, 4-inch.....	.....	.....	350	19	.....do.....	250.00	.....	Irrigation.....	.....	
981	.....do.....	.....do.....	H-12....	1901	.....do.....	34	34	350	19	.....do.....	250.00	.....	.....do.....	5	
982	.....do.....	.....do.....	H-12....	1901	.....do.....	34	34	350	19	.....do.....	250.00	.....	.....do.....	8	
983	.....do.....	.....do.....	H-12....	1901	.....do.....	34	34	350	19	.....do.....	250.00	.....	.....do.....	8	
984	.....do.....	.....do.....	H-13....	1903	.....do.....	25	25	336	21	.....do.....	252.00	.....	Domestic; irrigation.	20	
985	.....do.....	.....do.....	H-13....	1901	.....do.....	25	25	311	....	.....	224.20	.....	Irrigation.....	.....	
986	.....do.....	.....do.....	H-13....	1902	.....do.....	23	23	320	....	Artesian	240.00	.....	.....do.....	.....	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of l				
						Feet.	*Feet.*	*Feet.*						
987	Bixby Land Co	Los Alamitos	H-14	1895	Bored, 2-inch	23	23	260	19	Artesian	$150.00		Domestic	
988	do	do	H-14	1899	Hydraulic, 4-inch.	23	23	268	19	do	200.00		Irrigation	39
989	do	do	H-14	1900	do	23	23	268	19	do	200.00		do	35
990	do	do	H-14		Bored, 2-inch	21	21	260		do			Not used	
991	Fred Bixby	do	H-14	1903	Bored, 12-inch	21	21	848	17	do	2,500.00		Irrigation	306
992	do	do	G-14	1901	Bored, 8-inch	27	27	189	19	do			Domestic	14
993	Alamitos Beach Water Co.	do	F-14	1901	Bored, 12-inch	38	38	725	19	do	2,000.00		Domestic; irrigation.	137
994	do	do	F-14	1902	do	38	38	270	19	do			Irrigation; domestic.	61
995	do	do	F-14	1903?	do	40	40			do				
996	Mrs. M. Nelson	Los Cerritos	D-16	1892?	Bored, 4-inch	39	39	70	96	Wind			Domestic	
997	John Shrodes	do	D-16	1898	do	30	30	50?	200+	do			Stock	
998	People's Ice Plant	do	D-16	1903	Bored, 3-inch	42	12	70	200+		35.00		Factory	
999	M. E. Swingel	Los Alamitos	E-15	1900	Bored, 8-inch	41	15	60		Wind			Not used	
1000	W. A. Peck	do	E-16	1897	Bored, 7-inch	50	5	70		do			Irrigation	
1001	D. S. Shaw	do	E-16	1898	Bored, 8-inch	48	15	920	200+	do	3,500.00		do	
1002	Alamitos Beach Water Co.	do	G-16	1887	do	45	45	360	21				Not used	
1003	do	do	D-16	1895	Hydraulic, 2-inch.	45	45	114	19		50.00		do	
1004	Fred H. Bixby	do	H-16	1893	Bored, 2-inch	45	45	250	29	Artesian	150.00		Domestic	Small.
1005	do	do	H-16	1893	do	45	45	250	19	do	150.00		Irrigation	2
1006	do	do	I-16	1897	do	12	12	110	23	do	60.00		Domestic; stock.	Small.
1007	do	do	I-14	1902	Bored, 4-inch	13	13	375	31	do	350.00		Irrigation	31

1008	.....do.....	.....do.....	I-14.....	1902	.....do.....	13	13	375	25	.....do.....	350.00	.....	.....do.....	†42
1009	.....do.....	.....do.....	K-16.....	1902	.....do.....	18	18	300	26	.....do.....	300.00	.....	.....do.....	37
1010	.....do.....	.....do.....	K, L-15..	1902	.....do.....	20	20	350	25	.....do.....	325.00	.....	.....do.....	32
1011	.....do.....	.....do.....	M-15.....	1902	.....do.....	25	25	415	.....	.....do.....	375.00	.....	.....do.....	18
1012	.....do.....	.....do.....	L-15.....	1902	.....do.....	22	22	350	24	.....do.....	325.00	.....	.....do.....	28
1013	.....do.....	.....do.....	J-15.....	1895	Hydraulic, 2-inch.	12	12	250	26	.....do.....	150.00	.....	Stock.....	Small.
1014	.....do.....	.....do.....	K-15.....	1895	.....do.....	20	20	250	.....	.....do.....	150.00	.....	.....do.....	2
1015	.....do.....	.....do.....	M-15.....	1897	.....do.....	28	28	250	.....	.....do.....	150.00	.....	.....do.....	Small.
1016	.....do.....	.....do.....	L-16.....	.....	Bored, 7-inch.....	21	21	300	23	.....do.....	.....	.....	.....do.....	Small
1017	Bixby Land Co.....	.....do.....	I-14.....	1900	Bored, 4-inch.....	15	15	300	25	.....do.....	225.00	.....	Irrigation; domestic.	.....
1018	Wm. Carlson.....	.....do.....	I-14.....	1900	Hydraulic, 3-inch.	16	16	300+	21	.....do.....	140.00	.....	Domestic; irrigation.	14
1019	Bixby Land Co.....	.....do.....	I-14.....	1902	Bored, 2-inch.....	15	15	295	21	.....do.....	95.00	.....	Domestic.....	.....
1020	.....do.....	.....do.....	I-14.....	1902	Hydraulic, 2-inch.	14	14	309	23	.....do.....	115.00	.....	Domestic; irrigation.	11
1021	.....do.....	.....do.....	H-14.....	1902	Bored, 2-inch.....	15	15	300?	23	.....do.....	136.00	.....	Domestic.....	11
1022	.....do.....	.....do.....	I-14.....	1878?	.....do.....	16	16	300+	25	.....do.....	.....	.....	.....do.....	.....
1023	.....do.....	.....do.....	I-13.....	1900	Bored, 4-inch.....	19	19	350	21	.....do.....	.....	.....	Domestic; irrigation.	14
1024	.....do.....	.....do.....	I-13.....	1902	Hydraulic, 2-inch.	20	20	303	22	.....do.....	126.00	.....	Domestic.....	10
1025	.....do.....	.....do.....	H-13.....	1902	Bored, 12-inch....	21	21	882	..	.....do.....	4,000.00	.....	Irrigation.....	†95
1026	.....do.....	.....do.....	I-12.....	1902	.....do.....	25	25	740	22	.....do.....	3,500.00	.....	.....do.....	150
1027	J. H. Brown.....	.....do.....	H-13.....	1900	Hydraulic, 4-inch.	21	21	280	22	.....do.....	140.00	.....	Domestic.....	20
1028	Bixby Land Co.....	.....do.....	H-14.....	1901	Hydraulic, 2-inch.	16	16	300	21	.....do.....	140.00	.....	.....do.....	.....
1029	.....do.....	.....do.....	H-14.....	1891	Bored, 4-inch.....	21	21	268	21	.....do.....	150.00	.....	.....do.....	21
1030	J. Ross Clark.....	.....do.....	H-12.....	1890	Bored, 7-inch.....	..	....	500	25	.....do.....	.....	.....	Irrigation.....	42
1031	.....do.....	.....do.....	H-12.....	1900	Hydraulic, 2-inch.	32	32	312	23	.....do.....	150.00	.....	Domestic.....	.....
1032	.....do.....	.....do.....	G-11.....	1902	Bored, 4-inch.....	49	49	420	25	.....do.....	285.00	.....	Irrigation.....	.....
1033	.....do.....	.....do.....	H-11.....	.....	Bored, 2-inch.....	48	48	400?	25	.....do.....	.....	.....	Domestic.....	Small.
1034	Bixby Land Co.....	Los Cerritos.....	I-13.....	1895	Hydraulic, 2-inch.	23	23	300?	21	.....do.....	150.00	.....	.....do.....	.....
1035	I. W. Hellman.....	Los Alamitos.....	J-17.....	1898	Bored, 2-inch.....	30	30	200+	21	.....do.....	.....	.....	Domestic; stock.	Small.
1036	.....do.....	.....do.....	J-17.....	1898	.....do.....	28	24	145	25	Hand.....	7.00	.....	Domestic.....	.....
1037	.....do.....	.....do.....	J-17.....	1898	.....do.....	23	23	413	..	Artesian.....	.....	.....	Irrigation; domestic.	5
1038	.....do.....	.....do.....	K-17.....	.....	.....do.....	11	11	.....	...	.....do.....	.....	.....	Stock.....	.....
1039	.....do.....	.....do.....	K-17.....	1890?	Bored, 4-inch.....	12	12	250?	26	.....do.....	.....	.....	.....do.....	8

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
987	Bixby Land Co	Los Alamitos	H-14	1895	Bored, 2-inch	23	23	260	19	Artesian	$150.00		Domestic	
988	do	do	H-14	1899	Hydraulic, 4-inch	23	23	268	19	do	200.00		Irrigation	39
989	do	do	H-14	1900	do	23	23	268	19	do	200.00		do	35
990	do	do	H-14		Bored, 2-inch	21	21	260		do			Not used	
991	Fred Bixby	do	H-14	1903	Bored, 12-inch	21	21	848	17	do	2,500.00		Irrigation	306
992	do	do	G-14	1901	Bored, 8-inch	27	27	189	19	do			Domestic	14
993	Alamitos Beach Water Co.	do	F-14	1901	Bored, 12-inch	38	38	725	19	do	2,000.00		Domestic; irrigation.	137
994	do	do	F-14	1902	do	38	38	270	19	do			Irrigation; domestic.	61
995	do	do	F-14	1903?	do	40	40			do				
996	Mrs. M. Nelson	Los Cerritos	D-16	1892?	Bored, 4-inch	39	39	70	96	Wind			Domestic	
997	John Shrodes	do	D-16	1898	do	30	30	50?	200+	do			Stock	
998	People's Ice Plant	do	D-16	1903	Bored, 3-inch	42	12	70	200+		35.00		Factory	
999	M. E. Swingel	Los Alamitos	E-15	1900	Bored, 8-inch	41	15	60		Wind			Not used	
1000	W. A. Peck	do	E-16	1897	Bored, 7-inch	50	5	70		do			Irrigation	
1001	D. S. Shaw	do	E-16	1898	Bored, 8-inch	48	15	920	200+	do	3,500.00		do	
1002	Alamitos Beach Water Co.	do	G-16	1887	do	45	45	360	21				Not used	
1003	do	do	D-16	1895	Hydraulic, 2-inch	45	45	114	19		50.00		do	
1004	Fred H. Bixby	do	H-16	1893	Bored, 2-inch	45	45	250	29	Artesian	150.00		Domestic	Small.
1005	do	do	H-16	1893	do	45	45	250	19	do	150.00		Irrigation	2
1006	do	do	I-16	1897	do	12	12	110	23	do	60.00		Domestic; stock.	Small.
1007	do	do	I-14	1902	Bored, 4-inch	13	13	375	31	do	350.00		Irrigation	31

1008	....do....	....do....	I-14....	1902	....do....	13	13	375	25	....do....	350.00	....	....do....	†43
1009	....do....	....do....	K-16....	1902	....do....	18	18	300	26	....do....	300.00	....	....do....	37
1010	....do....	....do....	K, L-15.	1902	....do....	20	20	350	25	....do....	325.00	....	....do....	32
1011	....do....	....do....	M-15....	1902	....do....	25	25	415	....	....do....	375.00	....	....do....	18
1012	....do....	....do....	L-15....	1902	....do....	22	22	350	24	....do....	325.00	....	....do....	28
1013	....do....	....do....	J-15....	1895	Hydraulic, 2-inch.	12	12	250	26	....do....	150.00	....	Stock....	Small.
1014	....do....	....do....	K-15....	1895	....do....	20	20	250	....	....do....	150.00	....	....do....	2
1015	....do....	....do....	M 15....	1897	....do....	28	28	250	....	....do....	150.00	....	....do....	Small.
1016	....do....	....do....	L 16....	....	Bored, 7-inch....	21	21	300	23	....do....	....	....	....do....	Small
1017	Bixby Land Co....	....do....	I-14....	1900	Bored, 4-inch....	15	15	300	25	....do....	225.00	....	Irrigation; domestic.	....
1018	Wm. Carlson....	....do....	I-14....	1900	Hydraulic, 3-inch.	16	16	300+	21	....do....	140.00	....	Domestic; irrigation.	14
1019	Bixby Land Co....	....do....	I 14....	1902	Bored, 2-inch....	15	15	295	21	....do....	95.00	....	Domestic....	....
1020	....do....	....do....	I 14....	1902	Hydraulic, 2-inch.	14	14	309	23	....do....	115.00	....	Domestic; irrigation.	11
1021	....do....	....do....	H-14....	1902	Bored, 2-inch....	15	15	300?	23	....do....	136.00	....	Domestic....	11
1022	....do....	....do....	I-14....	1878?	....do....	16	16	300+	25	....do....	....	....	....do....	....
1023	....do....	....do....	I-13....	1900	Bored, 4-inch....	19	19	350	21	....do....	....	....	Domestic; irrigation.	14
1024	....do....	....do....	I-13....	1902	Hydraulic, 2-inch.	20	20	303	22	....do....	126.00	....	Domestic....	10
1025	....do....	....do....	H-13....	1902	Bored, 12-inch....	21	21	882	....	....do....	4,000.00	....	Irrigation....	†95
1026	....do....	....do....	I-12....	1902	....do....	25	25	740	22	....do....	3,500.00	....	....do....	150
1027	J. H. Brown....	....do....	H-13....	1900	Hydraulic, 4-inch.	21	21	280	22	....do....	140.00	....	Domestic....	20
1028	Bixby Land Co....	....do....	H-14....	1901	Hydraulic, 2-inch.	16	16	300	21	....do....	140.00	....	....do....	....
1029	....do....	....do....	H-14....	1891	Bored, 4-inch....	21	21	268	21	....do....	150.00	....	....do....	21
1030	J. Ross Clark....	....do....	H-12....	1890	Bored, 7-inch....	....	....	500	25	....do....	....	....	Irrigation....	42
1031	....do....	....do....	H-12....	1900	Hydraulic, 2-inch.	32	32	312	23	....do....	150.00	....	Domestic....	....
1032	....do....	....do....	G-11....	1902	Bored, 4-inch....	49	49	420	25	....do....	285.00	....	Irrigation....	....
1033	....do....	....do....	H-11....	....	Bored, 2-inch....	48	48	400?	25	....do....	....	....	Domestic....	Small.
1034	Bixby Land Co....	Los Cerritos....	I-13....	1895	Hydraulic, 2-inch.	23	23	300?	21	....do....	150.00	....	....do....	....
1035	I. W. Hellman....	Los Alamitos....	J-17....	1898	Bored, 2-inch....	30	30	200+	21	....do....	....	....	Domestic; stock.	Small.
1036	....do....	....do....	J-17....	1898	....do....	28	24	145	25	Hand....	7.00	....	Domestic....	....
1037	....do....	....do....	J-17....	1898	....do....	23	23	413	....	Artesian....	....	....	Irrigation; domestic.	5
1038	....do....	....do....	K-17....	....	....do....	11	11	....	....	....do....	....	....	Stock....	....
1039	....do....	....do....	K-17....	1890?	Bored, 4-inch....	12	12	250?	26	....do....	....	....	....do....	8

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1040	I. W Hellman	Los Alamitos	K-17	1897?	Hydraulic, 4-inch.	12	12	150		Artesian			Stock	†8
1041	do	do	L 17	1895	Bored, 7-inch	16	16	151		do			do	19
1042	do	do	L-16	1902	Bored, 2-inch	17	17	280		do	$140.00		Irrigation	8
1043	do	do	K-16	1899	Bored, 4-inch	14	14	120	25	do	40.00		do	25
1044	do	do	K 17	1899	Bored, 2-inch	19	19	120		do			Not used	
1045	do	do	L 16	1900	do	14	14	180		do	65.00		Irrigation	7
1046	do	do	K 16	1899	do	15	15	185	25	do	65.00		Domestic	
1047	do	do	K 16	1900	Bored, 4-inch	15	15	125	25				Irrigation	1
1048	do	do	K 16	1901	Bored, 2-inch	16	16	265	26	Artesian	75.00		do	2
1049	do	do	K 16	1897	do			100	26	do			do	3
1050	do	do	L 16	1901	do	16	16	130	25	do	75.00		do	4
1051	do	do	K 16	1900	Bored, 4-inch	17	17	250	25	do	180.00		do	1
1052	do	do	M 17	1901	do	23	23	340		do			Irrigation; domestic.	22
1053	David Rodgers	do	M-17	1901	do	19	19	269	29	do	162.00		Stock	
1054	do	Las Bolsas	M-17	1901	Bored, 3-inch	19	19	274	28	do	150.00		do	8
1055	do	do	M-17	1899	Bored, 2-inch	19	19	285	27	do	140.00		Domestic; stock.	5
1056	J. R. Robinson	do	M-17	1902	Bored, 4-inch	21	21	270	26	do	175.00		Irrigation	8
1057	David Rodgers	do	M-17	1897	Bored, 2-inch	23	23	330	28	do			Domestic	
1058	J. R. Robinson	do	M-17	1893	do	22	22	250?	26	do			Irrigation	4
1059	do	do	M 17	1893	do	22	22	250?		do			do	4
1060	D. R. Schaffer	do	M-17	1900	do	23	23	250	28	do	125.00		Irrigation; domestic.	4
1061	do	do	M 17	1900	do	22	22	250?	22	do	125.00		Irrigation	4

1062	.....do.....	.....do.....	M-17....	1900	.....do.....	22	22	250?	25	.....do.....	125.00	.....	.....do.....	4
1063	T. Willetts.....	.....do.....	M-17....	1897	.....do.....	23	23	100	26	.....do.....	100.00	.....	Domestic.....	5
1064	.....do.....	.....do.....	M-17....	1897	.....do.....	23	23	195	24	.....do.....	100.00	.....	Irrigation.....	8
1065	Geo. Berenstein.....	.....do.....	M-17....	1899	.....do.....	21	21	190	28	.....do.....	100.00	.....	Domestic.....	2
1066	.....do.....	.....do.....	M 17....	1899	.....do.....	23	22	190	27	.....do.....	.....	.....	Irrigation.....	3
1067	.....do.....	.....do.....	M-17....	1893	Bored, 7-inch.....	22	22	90	27	.....do.....	100.00	.....	Stock.....	Small.
1068	.....do.....	.....do.....	M 17....	1890	.....do.....	23	23	150?	26	.....do.....	.....	.....	.....do.....	7
1069	Mr. Sharp.....	.....do.....	M-17....	1892?	Bored, 2-inch.....	23	23	200?	27	.....do.....	.....	.....	Domestic; irrigation.	3
1070	H. C. Woodward & Co	.....do.....	M-17....	1886	Bored, 7-inch.....	23	23	333	29	.....do.....	.....	.....	Domestic.....	†2
1071	Mr. E. B. Finley.....	.....do.....	N-17....	1888	.....do.....	26	26	150	27	.....do.....	150.00	.....	.....do.....	Small.
1072	.....do.....	.....do.....	N 17....	1898	Bored, 2-inch.....	25	25	300	26	.....do.....	90.00	.....	Irrigation.....	6
1073	O. J. Buck.....	.....do.....	N 17....	1878	Bored, 7-inch.....	25	25	80	25	.....do.....	120.00	.....	Domestic.....	4
1074	J. H. Edwards.....	.....do.....	N 17....	1898	Bored, 2-inch.....	27	27	380	26	.....do.....	.....	.....	.....do.....	4
1075	.....do.....	.....do.....	N-17....	1880?	Bored, 7-inch.....	27	27	370?	26	.....do.....	.....	.....	Not used.....	.....
1076	.....do.....	.....do.....	N 17....	1899	Bored, 3-inch.....	27	27	360	26	.....do.....	.....	.....	Irrigation.....	11
1077	.....do.....	.....do.....	N-17....	1898	Bored, 2-inch.....	28	28	360	27	.....do.....	.....	.....	.....do.....	.....
1078	.....do.....	.....do.....	N-17....	1895	Bored, 7-inch.....	28	28	370	26	.....do.....	530.00	.....	.....do.....	29
1079	.....do.....	.....do.....	N-17....	1880?	.....do.....	28	28	.....	.....	.....do.....	.....	.....	Not used.....	.....
1080	W. G. Alford.....	.....do.....	N-17....	1880	.....do.....	27	27	300	28	.....do.....	.....	.....	Domestic.....	†1
1081	Sampson Edwards.....	.....do.....	N-17....	1897	Bored, 2-inch.....	27	27	300?	28	.....do.....	.....	.....	Not used.....	.....
1082	Mrs. Clark.....	.....do.....	N-17....	1888	Bored, 7-inch.....	29	29	.....	33	.....do.....	.....	.....	Domestic.....	†1
1083	Miss Beckworth.....	.....do.....	N-17....	1888?	Bored, 2-inch.....	89	89	100?	29	.....do.....	.....	.....	.....do.....	Small.
1084	F. Wright.....	.....do.....	N-17....	1901	Bored, 6-inch.....	31	31	100	34	.....do.....	.....	.....	Domestic; irrigation.	2
1085	L. Hosking.....	.....do.....	N-17....	1883?	Bored, 4-inch.....	32	32	100	33	.....do.....	.....	.....	Domestic.....	17
1086	Mrs. Stewart.....	.....do.....	N-17....	1890?	Bored, 2-inch.....	31	31	100?	34	.....do.....	.....	.....	.....do.....	Small.
1087	J. Caldwell.....	.....do.....	N-17....	1899	.....do.....	33	33	90	32	.....do.....	.....	.....	.....do.....	.....
1088	Mrs Harper.....	.....do.....	N-17....	.....	Bored, 3-inch.....	31	31	100?	27	.....do.....	.....	.....	.....do.....	.....
1089	Robert McClintock.....	.....do.....	N-17....	1899	Bored, 2-inch.....	31	31	.....	31	.....do.....	.....	.....	Domestic; stock.	†1
1090	E. E. Buck.....	.....do.....	N-17....	1900	.....do.....	31	31	100	29	.....do.....	.....	.....	Domestic.....	.....
1091	J. F. Patterson.....	.....do.....	N-17....	1894	.....do.....	33	33	111	27	.....do.....	42.00	.....	.....do.....	4
1092	Presbyterian parsonage.	.....do.....	N-17....	1902	.....do.....	33	33	110	27	.....do.....	50.00	.....	.....do.....	6
1093	H. Flowers.....	.....do.....	N-17....	1890?	Bored, 4-inch.....	33	33	85	31	.....do.....	.....	.....	.....do.....	.....
1094	F. F. Skelley.....	.....do.....	N-17....	1895	Bored, 2-inch.....	33	33	142	29	.....do.....	70.00	.....	.....do.....	.....

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1095	F. F. Skelley	Las Bolsas	N-17	1903	Bored, 2-inch	33	33	112	28	Artesian	$60.00		Domestic; irrigation	
1096	W. E. Lossing	do	N-17	1880	Driven, 2-inch	33	33	75	32	do			Domestic	
1097	do	do	N-17	1892	Bored, 2-inch	31	31	80	33	do	60.00		do	
1098	P. E. Niles	do	N 17	1902	do	32	32	335	24	Wind, artesian	140.00		do	
1099	R. T. Harris	do	N-17	1883	Bored, 4-inch	32	32	165	26	Artesian			do	
1100	C. W. Baker	do	N 17	1895	Bored, 2-inch	32	32	80	32	do	21.00		do	
1101	John Reed	do	N 17	1899	do	31	31	110	26	do			do	
1102	Methodist Episcopal parsonage	do	N 17	1902	do	31	31	70	....	Artesian, hand	60.00		do	
1103	Wm. James	do	N 17	1901	do	31	31	.....	27	Artesian			Irrigation	Small.
1104	Mr. Kiefhaber	do	N 17	1891	Bored, 7-inch	31	31	375	27	do	500.00		Domestic; irrigation	9
1105	Westminster Cheese and Butter Co	do	N 17	1895	Bored, 2-inch	30	30	80	.....	do	40.00		Not used	
1106	J. R. Davis	do	N 17	1902	Bored, 3-inch	30	30	366	29	do	180.00		Irrigation	9
1107	J. B. Lowsing	do	N-17	1897	Bored, 2-inch	29	29	366	28	do	150.00		Domestic	
1108	C. W. Baker	do	N-17	1897	do	36	36	187	.....	do	60.00		do	
1109	C. C. Violett	do	N-17	1899	do	35	35	125	31	do			do	
1110	C. E. Hammond	do	N-17	1899	do	34	34	106	28	do	50.00		do	
1111	R. Ward	do	N-17	1897	do	30	30	80	33	do	35.00		Domestic; irrigation	†4
1112	Wm. Harvey	do	N-17	1899	do	28	28	395	29	do	60.00		do	2
1113	do	do	N 17	1874?	Bored, 7-inch	28	28	96	29	do			Stock	Small.
1114	do	do	N 17	1875	do	28	28	96	29	do			Irrigation	1
1115	Sam Waters	do	N-17	1894	Bored, 3-inch	30	30	80	28	do	30.00		do	Small.

1116	.....do.....	.....do.....	N-17....	1873	Bored, 4-inch.....	30	30	83	28	.....do.....	50.00	.....	Domestic; irrigation.	Small.
1117	J. R. Cavanah.....	.....do.....	N-17....	1878	Bored, 7-inch.....	29	29	100+	28	.....	.....	.....	Not used.....	.....
1118	.....do.....	.....do.....	N-17....	1889	Bored 4-inch.....	29	29	100+	28	Hand, artesian.....	.....	.....	Domestic.....	Small.
1119	.....do.....	.....do.....	N-17....	1898	Bored, 2-inch.....	31	31	325	28	.....do.....	.....	.....	Irrigation; domestic.	Small.
1120	.....do.....	.....do.....	N-17....	1899	Bored, 4-inch.....	29	29	325	28	.....do.....	.....	.....	Irrigation.....	5
1121	R. Naukervis.....	.....do.....	N-17....	1900	Bored, 2-inch.....	27	27	.....	24	Artesian.....	30.00	.....	Domestic; irrigation.	.....
1122	John White.....	.....do.....	M-17....	1883?	Bored, 7-inch.....	29	29	.....	25	.....do.....	.....	.....	Domestic.....	Small.
1123	R. Naukervis.....	.....do.....	M-17....	1888	.....do.....	27	27	250	.....	.....do.....	200.00	.....	.....do.....	Small.
1124	Wm. Yeo.....	.....do.....	N-17....	1895	Bored 2-inch.....	31	31	80	.....	.....do.....	35.00	.....	.....do.....	Small.
1125	.....do.....	.....do.....	N-17....	1898	Bored 3-inch.....	33	33	400	29	.....do.....	150.00	.....	Stock.....	2
1126	Geo. Phillips.....	.....do.....	N-16....	.....	Bored, 7-inch.....	38	38	250	32	.....do.....	.....	.....	Not used.....	.....
1127	.....do.....	.....do.....	N-16....	1891	Bored, 4-inch.....	42	24	250	32	.....do.....	.....	.....	Domestic; irrigation.	5
1128	.....do.....	.....do.....	N-16....	1888?	Bored, 7-inch.....	41	41	250	26	.....do.....	.....	.....	Stock.....	Small.
1129	C. A. Phelps.....	.....do.....	N-16....	.....	Bored, 2-inch.....	45	45	.....	28	.....do.....	.....	.....	Domestic.....	.....
1130	G. K. Lien.....	.....do.....	N-16....	1901	Bored, 4-inch.....	38	38	275	27	.....do.....	300.00	.....	Domestic; irrigation.	.....
1131	.....do.....	.....do.....	N-16....	.....	Bored 8-inch.....	38	38	200+	27	.....do.....	.....	.....	Stock.....	.....
1132	C. W. Dickey.....	.....do.....	N-16....	1883	Bored, 7-inch.....	41	41	230	27	.....do.....	.....	.....	Domestic; stock.	Small.
1133	.....do.....	.....do.....	N-16....	1897	Bored 3-inch.....	41	41	211	27	.....do.....	75.00	.....	Irrigation.....	5
1134	.....do.....	.....do.....	N-16....	1897	Bored, 7-inch.....	41	41	230	27	.....do.....	288.00	.....	.....do.....	Small.
1135	Geo. Abbott.....	.....do.....	N-16....	1890?	.....do.....	40	40	78	25	Wind, artesian.....	.....	.....	Not used.....	.....
1136	Mrs. Lucy Roberts ...	.....do.....	N-16....	.....	Bored, 2-inch.....	41	41	100+	22	Artesian.....	.....	.....	Domestic; irrigation.	Small.
1137	E. D. Barton.....	.....do.....	N-16....	1880?	Bored, 7-inch.....	42	42	230	26	.....do.....	500.00	.....	Domestic.....	.....
1138	.....do.....	Los Alamitos.....	N-16....	1899	.....do.....	43	43	230	26	.....do.....	400.00	.....	Stock.....	Small.
1139	I. W. Hellman.....	.....do.....	N-15....	1886?	.....do.....	39	39	.....	26	.....do.....	.....	.....	.....do.....	Small.
1140	G. D. Neil.....	Los Coyotes.....	N-14....	1896	Bored, 2-inch.....	48	48	150	24	.....do.....	60.00	.....	Domestic; irrigation.	Small.
1141	.....do.....	.....do.....	N-14....	1899	.....do.....	53	53	150	29	.....do.....	70.00	.....	Irrigation; stock.	Small.
1142	J. Klemm.....	.....do.....	N-14....	1897	.....do.....	58	58	287	26	Artesian, wind..	180.00	.....	Domestic.....	.....
1143	John Wolff.....	.....do.....	N-13....	1898	.....do.....	58	....	149	27	Hand.....	70.00	.....	.....do.....	.....
1144	F. Jabs.....	.....do.....	N-13....	1898	.....do.....	58	58	165	28	Artesian.....	.....	.....	Stock; domestic.	Small.
1145	A. Dargetz.....	.....do.....	N-13....	1898	.....do.....	58	58	181	27	.....do.....	60.00	.....	Domestic.....	Small.

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1146	J Jabs	Los Coyotes	N 13	1896	Bored, 2-inch	60	60	300+	26	Artesian	$105.00		Domestic; stock.	Small
1147	W J Cole	do	N 13	1892	Bored, 7-inch	60	58	189	26	Wind; gas	235.00		Domestic; irrigation	†30
1148	do	do	N-13	1901	do	53	51	189	27	Wind	190.00		Stock; irrigation	
1149	J Seaman	do	N 13	1902	Bored, 4-inch	59	52	106	27	do	90.00		Domestic	
1150	H Hansen	do	N 12	1900	Bored, 6-inch	59	54	156	26	Gas	140.00	$318.00	Domestic; irrigation	†18
1151	do	do	N 12	1896	Bored, 2-inch	59		274	26	do	97.00		do	
1152	S Huff	do	N 12	1903	Bored, 7-inch	62	56	170	25	Wind		125.00	do	
1153	do	do	N 12	1896	Bored, 2-inch	62		170	25	Hand			Domestic	
1154	Mr Kruger	do	N 12	1900	Bored, 1¼-inch	63			31	do			do	
1155	Bixby Land Co	Los Alamitos	M 14	1902	Bored 4-inch	38	38	471	27	Artesian	385.20		Irrigation	22
1156	do	do	M 14	1901	do	36	36	380	24	do	220.00		do	27
1157	do	do	M-14	1901	do	36	36	365	25	do	220.00		do	27
1158	do	do	M 14	1901	do	36	36	359	25	do	225.00		do	24
1159	do	do	M 14	1901	do	33	33	396	28	do	250.00		do	30
1160	do	do	M-14	1901	do	33	33	368	26	do	225.00		do	26
1161	do	do	M-14	1901	do	33	33	358	25	do	225.00		do	24
1162	do	do	M-14	1901	do	32	32	362	25	do	225.00		do	21
1163	do	do	M 14	1901	do	32	32	358	25	do	225.00		do	17
1164	do	do	L 15	1902	do	24	24	466	28	do	400.00		do	38
1165	do	do	K 14	1901	do	23	23	418	26	do	350.00		do	31
1166	do	do	K 14	1902	do	18	18	316	28	do	300.00		Domestic	21
1167	do	do	K 14	1900	Bored, 2-inch	19	19	358	28	do	150.00		do	6

1168	.....do.....	.....do.....	K-14....	1897	.....do.....	19	19	360	....	.....do.....	.....	.....do.....	6
1169	.....do.....	.....do.....	J-14.....	1901	.....do.....	15	15	350	27	.....	.....	.....do.....	9
1170	.....do.....	.....do.....	M-14.....	1888	.....do.....	37	37	150	27	Artesian	.....	.....do.....	Small.
1171	Mr Stump.....	Los Coyotes.....	M 14.....	1900	Bored 4-inch.....	42	42	375?	26	.....do.....	.....	Irrigation.....	26
1172	Bixby Land Co.....	Los Alamitos.....	M 14.....	1890?	Bored, 2-inch.....	36	36	.....	27	.....do.....	.....	Domestic.....	.....
1173	Fred Bixby.....	.....do.....	J-14, 15..	1899	.....do.....	14	14	117	....	.....do.....	.....	Irrigation; domestic.	.....
1174	Southern Pacific Co..	.....do.....	K-14.....	1896	Bored, 8-inch.....	20	20	.....	28	Wind.....	.....	Engines.....	.....
1175	Los Alamitos Sugar Co	.....do.....	K-14.....	1896	Bored, 2-inch.....	20	20	708	....	.....	250.00	Not used.....	.....
1176	.....do.....	.....do.....	J 14.....	1897	Bored, 10-inch....	20	20	560	31	Artesian.....	.....	Irrigation; factory.	.....
1177	.....do.....	.....do.....	J 14.....	1897	.....do.....	20	20	473	....	Artesian; compressed air	.....	Factory.....	†20
1178	.....do.....	.....do.....	J 14.....	1897	.....do.....	19	19	439	29	.....do.....	.....	.....do.....	†15
1179	.....do.....	.....do.....	K-14.....	1897	.....do.....	19	19	443	29	Artesian.....	.....	Not used.....	.....
1180	.....do.....	.....do.....	K 14.....	1897	.....do.....	19	19	469	30	Artesian; compressed air	.....	Factory.....	†15
1181	.....do.....	.....do.....	K 13, 14.	1901	Bored, 12-inch....	19	19	560	28	Artesian.....	.....	.....do.....	†15
1182	.....do.....	.....do.....	K-13, 14.	1901	.....do.....	19	19	696	30	.....do.....	.....	.....do.....	†15
1183	.....do.....	.....do.....	K-13, 14.	1901	.....do.....	19	19	576	27	Artesian; compressed air.	.....	.....do.....	†15
1184	.....do.....	.....do.....	K-14.....	1903	Bored, 2-inch.....	21	21	412	29	Artesian.....	165.00	Stock.....	†4
1185	P G Labourdette.....	.....do.....	J-13, 14 .	1892	.....do.....	18	18	300?	25	.....do.....	.....	Domestic.....	.....
1186	Bixby Land Co.....	.....do.....	J-13.....	1900	Bored, 4-inch.....	21	21	410	25	.....do.....	250.00	Irrigation; domestic.	14
1187	.....do.....	.....do.....	J-13.....	1903	.....do.....	22	22	385	28	.....do.....	225.00	Domestic.....	.....
1188	H H Bartlett.....	.....do.....	K-13.....	1893	Bored, 3-inch.....	20	20	250	29	.....do.....	.....	Domestic; irrigation.	†1
1189	L Dyke.....	.....do.....	K-13.....	1895?	Bored 2-inch.....	20	20	350?	27	.....do.....	.....	Domestic.....	.....
1190	E H Dyer.....	.....do.....	K-13.....	1897	.....do.....	23	23	512	26	.....do.....	.....	Stock; irrigation	Small.
1191	.....do.....	.....do.....	K-13.....	1902	Bored, 3-inch.....	23	23	505	27	.....do.....	272.70	Irrigation.....	†9
1192	D R Proffer.....	Los Coyotes.....	K 13.....	1897	Bored, 2-inch.....	23	23	306	....	Wind.....	36.00	Domestic.....	Small.
1193	.....do.....	Los Alamitos.....	K-13.....	1897	.....do.....	22	22	416	27	Artesian.....	160.00	Irrigation.....	Small.
1194	H J. Proffer.....	Los Coyotes.....	K-13.....	1898	.....do.....	23	23	352	26	.....do.....	110.00	Domestic.....	Small.
1195	Bixby Land Co.....	Los Alamitos.....	J 12.....	1896	.....do.....	23	23	90	22	.....do.....	45.00	Stock.....	Small.
1196	.....do.....	.....do.....	J-13.....	1896	.....do.....	25	25	160	....	.....do.....	60.00	Domestic.....	Small.

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1197	Los Alamitos Sugar Co	Los Alamitos	K-13	1896	Bored, 3-inch	26	26	375?	28	Artesian			Domestic	
1198	Theo. D. Hewitt	do	L-13	1898	do	34	34	300	26	do			do	
1199	do	Los Coyotes	M-13	1900	Bored, 4-inch	42	42	480	27	do			Irrigation	15
1200	J. W. Swope	do	M-13	1868?	Bored, 6-inch	42	42	100		do			Domestic	
1201	Bixby Land Co	Los Alamitos	L-14	1865?	Bored, 9½-inch	37	37	100	25	do			Not used	
1202	Gus Hansen	Los Coyotes	M-13	1883	Bored, 7-inch	44	44	270	26	do			Irrigation	12
1203	do	do	M-13		Bored, 2-inch	43	43			do			do	Small.
1204	do	do	M-13	1902	Bored, 12-inch	42	42	567	32	do	$1,500.00		do	47
1205	Geo. Burrows	do	N-14	1898	Bored, 2-inch	48	48		25	do			Domestic	
1206	A. Kratzer	do	N-13	1898	Bored, 3-inch	52	52	144	26	do	57.00		do	3
1207	Mrs. S. R. Edgerly	do	N-13	1895	Bored, 2-inch	52	52	175	27	Artesian, hand			do	Small.
1208	do	do	N-13		Bored, 7-inch	52	52	420	28	Artesian			Stock	Small.
1209	F. Gruenkey	do	N-13	1890?	Bored, 3-inch	49	49	300	26	Artesian, hand			Domestic	Small.
1210	do	do	N-13	1893	Bored 2-inch	48	48	190	27	Artesian			Irrigation	Small.
1211	H. Krueger	do	N-13	1883	Bored, 10-inch	48	48	200	27	do	250.00		Domestic	1
1212	do	do	M-13	1899	Bored, 3-inch	48	48	160	27	do	70.00		Irrigation	Small.
1213	W. H. Musser	do	M-13	1896	Bored, 2-inch	50	50	560	26	do			do	
1214	Wm. Elliott	do	M-13	1898	do	37	37	300	23	do			Not used	
1215	W. T. Sparks	do	L-13	1895	do	27	27	437		do			Domestic	3
1216	Wm. Elliott	do	M-13	1898	do	38	38	300		do			Not used	
1217	Cypress school district	do	L-13	1896	do	27	27	336	28	do	125.00		Domestic	
1218	C. L. Damron	do	L-13	1896	do	31	31	300	28	do	150.00		Domestic; irrigation.	

1219	F Thompson	do	L-13	1898	do	32	32	560		do	225.00		do	1
1220	L. Deuni	do	L-13	1896	do	31	31	577	28	do	216.37		Irrigation	1
1221	A. J. Damron	do	L-12	1896	do	32	32	530		do	170.00		do	Small.
1222	do	do	L-12	1894	do	32	32	330		do	110.00		Domestic; irrigation.	Small.
1223	do	do	L-12	1897	do	35	35	536	29	do	170.00		Irrigation	5
1224	do	do	M-12	1897	do	39	39	500	29	do	150.00		Irrigation; stock	2
1225	do	do	M-13	1896	do	39	39	300	28	do	110.00		Stock	Small.
1226	J. C. & J. S. Tucker	do	M-13	1890?	do	44	44	400?	26	do			Domestic; irrigation.	Small.
1227	J. P. Street	do	M-12	1895	do	44	44	325	28	do	130.00		Irrigation	Small.
1228	do	do	M-12	1899	do	44	44	525	27	do	175.00		Irrigation; domestic.	†4
1229	J. A. Hollingsworth	do	M-13	1902	Bored, 3-inch	45	45	580	28	do			Irrigation	2
1230	do	do	M-13	1900	Bored, 2-inch	45	45	580	28	do			Irrigation; domestic.	
1231	B. F. La Rue	do	M-13	1897	do	50	50	270	27	do			do	1½
1232	do	do	M-13	1897	Bored, 7-inch	50	50	270	28	do	500.00		Irrigation	Small.
1233	Chas. Burrows	do	M-12	1895	Bored 2-inch	52	52	500	29	do	175.00		Domestic	4
1234	D. L. Whitney	do	N-12	1895	do	53	53	500	28	do	175.00		do	Small.
1235	O. P. Bunyard	do	N-13	1897	do	53	53	527	28	do			do	Small.
1236	E. P. Wright	do	N-13	1883	Bored, 4-inch	50	50	200	27	Hand			do	
1237	L. Seaman	do	N-12	1902	Bored, 3-inch	58	51	100	25	do			do	
1238	Geo. Burrows	do	N-12	1898	Bored 2-inch	53	53	500		Artesian	150.00		do	Small.
1239	G. B. Hemphill	do	N-12	1899	do	54	53	550			350.00		Not used	
1240	do	do	N 12	1894	do	54	53	190	26	Hand			Domestic	
1241	J. W. Miller	do	K-12	1888?	Bored, 4-inch	25	25	200?	27	Artesian			do	Small.
1242	do	do	K-12		Bored, 2-inch	25	25	200?		do			Stock	Small.
1243	Chas. Thornton	do	K-12	1896	do	24	24	560	28	do	205.00		Domestic; stock	Small.
1244	do	do	K-12	1900	do	24	24	560		do	225.00		Irrigation	5
1245	L. Deuni	do	K-13	1892	do	24	24	375	27	do	210.00		Domestic	Small.
1246	Louis Deuni	do	K-13	1895	do	23	23	566	27	do	212.30		Irrigation	
1247	L. H. Harling	do	K-13	1892	Bored, 7-inch	24	24	300?	26	do			Domestic	Small.
1248	do	do	K-13	1898	Bored, 2-inch	26	26	540	28	do	200.00		Irrigation	†1
1249	Mrs. J. D. Carter	do	K-12	1900	do	27	27	500?	29	do	300.00		Domestic	Small.
1250	do	do	L-13	1902	Bored, 4-inch	26	26	575	28	do			Irrigation	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1251	Mrs. E. R. Miller	Los Coyotes	L 12	1897	Bored, 2-inch	27	27	340	28	Artesian	$125.00		Domestic	Small.
1252	do	do	L 12	1900	do	28	28	590	28	do	300.00		Irrigation	3
1253	do	do	L-12	1897	do	28	28	340	27	do	125.00		do	Small.
1254	J. G. Hannah	do	L-12	1895	do	28	28	333	27	do	150.00		do	Small.
1255	do	do	L 12	1897	do	28	28	555	27	do	250.00		do	
1256	Geo. Nelson	do	K 12	1899	do	25	25	548	27	do			Domestic; irrigation.	
1257	W. R. Miller	do	K 12	1891	do	27	27	550	28	do			Stock	Small.
1258	C. C. Neff	do	K 12	1895	do	30	30	326	27	do	175.00		Domestic	
1259	Mr. Miller	do	K 12	1891	Bored, 4-inch	25	25	330		do	210.00		do	Small.
1260	James Bradie	do	L-12	1899	Bored, 3-inch	31	31	550	28	do	250.00		Irrigation	9
1261	J. H. Jackson	do	L 12	1894	do	31	31	330	27	do	170.00		do	
1262	W. R. Burnett	do	L-12	1895	Bored, 2-inch	32	32	326	27	do	150.00		Domestic; irrigation.	Small.
1263	Mrs. Sebastian	do	L-12	1895	do	35	35	330	27	do			Not used	
1264	L. Flippen	do	L 12	1898	do	30	30	500	27	do			Stock	Small.
1265	J. J. Feagan	do	L 12	1898	do	36	36	540	28	do	300.00		Domestic; stock	3
1266	do	do	L-12	1892	Bored, 7-inch	36	36	575	28	do	1,800.00		Irrigation	Small.
1267	do	do	L-12	1902	Bored, 12-inch	38	38	585	28	do	1,650.00		do	4
1268	do	do	L-12	1897	Bored, 2-inch	38	38	540	28	do			Irrigation; stock	Small.
1269	do	do	L-12	1897	do	39	39	596	28	do	300.00		Domestic	Small.
1270	J. C. Cawthon	do	M-12	1897?	do	33	33	500		do			do	Small.
1271	J. N. Stockton	do	L-12	1902	do	41	41	184	26	Hand			do	
1272	do	do	L-12	1898	do	42	42	400?	27	Artesian			Stock	Small.

1273	Mrs. R. J. Reeves	do	M-12	1894	do	45	45	300		Artesian, wind		Domestic	Small.
1274	C. R. Clausen	do	M-12	1900	do	46	46	540	29	Artesian	270.00	Irrigation	Small.
1275	do	do	M-12	1897	do	48	48	540	29	do	270.00	do	Small.
1276	do	do	M-12	1897	do	48	48	540	29	do	270.00	do	Small.
1277	do	do	M-12	1899	do	48	48	280	26	Wind	140.00	Domestic	
1278	Mr. A. R. Luedkey	do	M 12	1897	do	49	49	510		Artesian	170.00		Small.
1279	W. T. Preston	do	M 12	1898	do	52	52	500	28	do	150.00	Irrigation	Small.
1280	J. L. Preston	do	M-12	1898	do	53	53	500	29	do	140.00	Irrigation; domestic.	Small.
1281	Wm. Pechstein	do	M-12	1893	do	53	53	250		do	175.00	Domestic	Small.
1282	C. O. Walker	do	N 12	1896	Bored, 5-inch	55	55	260+		Gas		Irrigation	†50
1283	E. R. Holman	do	N-12	1893	Bored, 2-inch	60	59	500	27	Wind		Domestic	
1284	Wm. Abplanalp	do	N 12	1892	do	60	58	507		Horsepower		do	
1285	Mrs. Harrison	do	N-12	1893	do	59	59	100?	27	Hand		do	
1286	P. Mongofsky	do	N-12	1901	Bored, 3-inch	60	51	113	30	Wind	85.00	$80.00 do	
1287	Walter Bowen	do	N-12	1891?	Bored, 2-inch	67	58	180				Not used	
1288	Mrs. Laura Harrison	do	N-11	1892	do	68	60	256	28	Wind		Domestic	
1289	Geo. N. Frentz	do	N-11	1873	Bored, 7-inch	66	64	280	29	Rotary pump	1,000.00	do	
1291	J. L. Overton	do	N-11	1888	Bored, 2-inch	62	62	500+	28	Artesian		Domestic; irrigation.	Small.
1292	do	do	N-11	1893	do	63	63	280		do		Irrigation	
1293	A. W. Brooks	do	N-12	1893	Bored, 7-inch	60		80	27	Wind		Domestic	
1294	John O. Peterson	do	N-12	1901	Bored, 2-inch	60	52	80	27	Hand	30.00	do	
1295	do	do	N-12	1899	Bored, 3-inch	61	57	300		Wind	180.00	Irrigation	
1296	W. B. Pechstein	do	N-12	1903	do	57	51	152	27	do	75.00	20.00 Domestic	
1297	Centralia school district.	do	N-11	1897	Bored, 2-inch	60	60	486	30	Artesian	200.00	do	Small.
1298	John Terry	do	N-11	1900	Bored, 7-inch, 270 feet; 3-inch, 200 feet.	59	59	470	28	do	500.00	Irrigation	2
1299	do	do	N-11	1900	Bored, 3-inch	59	59	475	28	do	300.00	do	†3
1300	do	do	N-11	1900	Bored, 2-inch	59	59	475	28	do	150.00	Domestic	
1301	Mr. Cordiss	do	N-12	1897	do	57	57	290		do		Irrigation	Small.
1302	J. C. Roller	do	M-11	1896	do	53	53	200?	28	do		do	Small.
1303	do	do	M-11	1896	do	27	27		27	do		Stock	Small.
1304	do	do	M-11	1896	do	28	28		27	do		Irrigation	Small.
1305	D. Holder	do	M-11	1899	Hydraulic, 2-inch.	54	54	510	28	do		Domestic	Small.

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1306	J. Siems	Los Coyotes	N-12	1900	Bored, 2-inch	58	58	517	28	Artesian	$200.00		Stock	Small.
1307	do	do	N-12	1895	do	58	58	300		do			Irrigation	Small.
1308	C. Weber	do	M-12	1899	Bored, 7-inch	54	47?	104		Hand	80.00		Domestic	
1309	do	do	M-12	1897	Bored, 3-inch	54	54	515	28	Artesian	175.00		Stock	Small.
1310	do	do	M-12	1897	Bored, 2-inch	54	54	530	28	do	180.00		Irrigation	Small.
1311	do	do	M-12	1893	Bored, 7-inch	54	54	343	28		500.00		Not used	
1312	C. E. Carner	do	N-12	1898	Bored, 2-inch	58	58	520	27	Artesian	300.00		do	
1313	T. M. Laynaehan	do	M-11	1897	do	50	50	449	27	do	157.15		Irrigation; domestic.	1½
1314	do	do	M-11	1897	do	51	51	515	28	do	180.25		Domestic	Small.
1315	S. O. Walker	do	M-11	1897	do	48	48	292	29	Hand	120.00		do	
1316	do	do	M-12	1897	do	50	50	500?	31	Artesian	230.00		Irrigation	Small.
1317	do	do	M-12	1897	do	50	50	500		do	205.00		do	Small.
1318	do	do	M-12	1900	Bored, 3-inch	50	50	700	27	do	480.00		do	3
1319	W. D. Gilmore	do	M-12	1899	Bored, 2-inch	48	48	590	28	Artesian, wind	200.00		Stock	Small.
1320	do	do	M-12	1903	do	47	47	100	28	Wind	80.00		Domestic	
1321	Geo. D. Miller	do	M-12	1902	Bored, 10-inch	47	47	652	29	Artesian	1,700.00		Irrigation	1
1322	do	do	M-12	1890	Bored, 2-inch	47	47	286	27	do			Domestic; irrigation.	
1323	do	do	M-11	1896	do	47	47	396	27	do			Irrigation	
1324	G. Dewey	do	M-11		Bored, 7-inch	47	47		28	do	1,700.00		Not used	
1325	A. Larrecq	do	M-12	1902	Bored, 2-inch	42	40	135		Hand	65.00		Domestic	
1326	B. Mouliot	do	L-12	1899	do	39	39	569	28	Artesian	175.00		Irrigation	Small.
1327	do	do	L-12	1897	do	38	38	542	28	do	160.00		do	Small.

1328	.....do.....	.....do.....	L-12....	1897	.....do.....	37	37	531	28	.....do.....	160.00	.....	Domestic; irrigation.	Small.
1329	.....do.....	.....do.....	L-12....	1898	.....do.....	33	33	596	28	.....do.....	175.00	.....	Irrigation.....	2
1330	E. J. Behnke.....	.....do.....	L-11....	1892	Bored, 7-inch.....	37	37	316	28	Hand.....	600.00	.....	Stock.....	.....
1331	.....do.....	.....do.....	L-11....	1898	Bored, 2-inch.....	38	38	563	34	Artesian.....	160.00	.....	Not used.....	.....
1332	H. H. Corell.....	.....do.....	L-11....	1892	Bored, 7-inch.....	51	51	284	....	.....do.....	420.00	.....	Irrigation.....	.....
1333	.....do.....	.....do.....	L-11....	1897	Bored, 2-inch.....	37	37	554	28	.....do.....	.....	.....	.....do.....	Small.
1334	.....do.....	.....do.....	L-11....	1900	Bored, 3-inch.....	37	37	568	30	.....do.....	305.00	.....	.....do.....	†9
1335	J. P. Moody.....	.....do.....	M-11....	1900	.....do.....	35	35	541	28	.....do.....	300.00	.....	.....do.....	5
1336	.....do.....	.....do.....	L-11....	1885?	Bored, 7-inch.....	33	33	200	28	.....do.....	.....	.....	Domestic; irrigation.	Small.
1337	.....do.....	.....do.....	L-11....	1898	Bored, 3-inch.....	33	33	440	....	.....do.....	200.00	.....	Irrigation.....	Small.
1338	.....do.....	.....do.....	L-11....	1901	.....do.....	33	33	300	28	.....do.....	175.00	.....	.....do.....	2
1339	J. F. Sheldon.....	.....do.....	L-12....	1899	Bored, 2-inch.....	32	32	550?	27	.....do.....	.....	.....	.....do.....	Small.
1340	.....do.....	.....do.....	L-12....	1899	Bored, 3-inch.....	32	32	550?	28	.....do.....	.....	.....	.....do.....	1½
1341	.....do.....	.....do.....	L-12....	1893	Bored, 4-inch.....	31	31	300	27	.....do.....	.....	.....	Not used.....	.....
1342	Mr. Ermston.....	.....do.....	L-11....	1894	Bored, 7-inch.....	29	29	.....	25	.....do.....	.....	.....	Domestic; irrigation.	Small.
1343	O. Bell.....	.....do.....	K-11....	1900	Bored, 3-inch.....	29	29	220	28	.....do.....	.....	.....	Irrigation.....	9
1344	B. F. Draper.....	.....do.....	K-11....	1901	Bored, 2-inch.....	29	29	315	....	.....do.....	100.00	.....	Domestic; irrigation.	†4
1345	Mrs. M. A. Geoddel....	.....do.....	K-12....	1897	Bored, 3-inch.....	25	25	541	28	.....do.....	190.00	.....	.....	9
1346	.....do.....	.....do.....	K-12....	1870?	Bored, 7-inch.....	25	25	122	27	.....do.....	600.00	.....	Domestic.....	.....
1347	.....do.....	.....do.....	K-12....	1870?	.....do.....	26	26	132	27	.....do.....	600.00	.....	Irrigation.....	Small.
1348	Bloomfield district....	.....do.....	K-12....	1899	Bored, 2-inch.....	26	26	240	28	.....do.....	.....	.....	Domestic.....	Small.
1349	B. J. Jones.....	.....do.....	K-12....	1886	Bored, 7-inch.....	28	28	156	28	.....do.....	150.00	.....	Domestic; irrigation.	Small.
1350	.....do.....	.....do.....	K-12....	1898	.....do.....	28	28	224	28	.....do.....	250.00	.....	Irrigation.....	Small.
1351	.....do.....	.....do.....	K-12....	1901	Bored, 3-inch.....	28	28	555	28	.....do.....	315.00	.....	.....do.....	†12
1352	J. Swagard.....	.....do.....	K-12....	1893	.....do.....	28	28	500?	....	.....do.....	300.00	.....	Not used.....	.....
1353	.....do.....	.....do.....	K-12....	1898	.....do.....	28	28	500	27	.....do.....	300.00	.....	Irrigation.....	.....
1354	W. S. Grant.....	.....do.....	K-12....	1888	Bored, 7-inch.....	26	26	180	27	.....do.....	150.00	.....	Domestic.....	.....
1355	.....do.....	.....do.....	K-12....	1901	Bored, 3-inch.....	26	26	550	28	.....do.....	300.00	.....	Irrigation.....	†8
1356	H. Whipple.....	.....do.....	K-12....	1897?	Bored, 2-inch.....	25	25	350+	27	.....do.....	.....	.....	Domestic.....	.....
1357	.....do.....	.....do.....	K-12....	1898	Bored, 3-inch.....	25	25	580	28	.....do.....	.....	.....	Irrigation.....	2
1358	Fred Smith.....	.....do.....	J-12....	1896	Bored, 2-inch.....	25	25	165	26	.....do.....	50.00	.....	Domestic.....	.....
1359	.....do.....	.....do.....	J-12....	1898	Bored, 3-inch.....	25	25	201	28	.....do.....	92.00	.....	Irrigation.....	Small.

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1360	Fred Smith	Los Coyotes	J 12	1900	Bored, 3-inch	25	25	312	27	Artesian	$180.00		Irrigation	† 1
1361	Columbus Jackson	do	J 12	1898	Bored, 2-inch	28	28	173	25	do	52 00		Domestic; irrigation.	
1362	B. F. Draper	do	J 12	1898	do	28	28	300	27	do			Irrigation	
1363	do	do	J 12	1899	do	27	27	300	28	do			Stock	† 1
1364	do	do	J 12	1902	do	27	27	300	28	do				Small.
1365	L. A. Goodrich	do	J 12	1900	Bored, 3-inch	25	25	230	24	do			Domestic, irrigation.	
1366	Anson Woodon	do	J 12	1898	Bored, 2-inch	28	28	300	24	do	150.00		Domestic, stock	
1367	H. L. Gordon	do	J 12		do	27	27		24	do			Domestic.	
1368	do	do	J 12		Bored, 7-inch	27	27			do			Stock	Small
1369	do	Los Cerritos	I 12		Bored, 4-inch	27	27		24	do			Irrigation	† 1
1370	do	do	I 12		Bored, 10-inch	28	28		26	do			do	Small.
1371	do	do	I 12		Bored, 4-inch	28	28		27	do			do	† 1
1372	do	do	I 12		do	28	28		27	do			do	† 1
1373	do	do	I 12		do	28	28		26	do			do	† 1
1374	do	do	I 12		Bored, 2-inch	29	29		21	do			do	Small.
1375	do	do	I 12		Bored, 4-inch	29	29		21	do			do	† 1
1376	do	do	I 12		do	29	29		21	do			do	† 1
1377	do	do	I 12		do	29	29		21	do			do	† 1
1378	do	do	I 12		do	27	27		26	do			do	† 2
1379	do	do	J 12		do	26	26		24	do			do	4
1380	do	do	J 12		do	26	26		26	do			do	4
1381	do	do	J 12		do	26	26		26	do			do	4

1382	W. J. Woodin	Los Coyotes	J 11	1894	Bored, 2-inch	31	31	240	22	do	135.00		Domestic	Small.
1383	do	do	J-11	1886	Bored, 7-inch	31	31	240	26	do	300.00		Stock	Small.
1384	S. L. Leighton	do	J-11	1885	do	31	31	243	25	do			Domestic	Small.
1385	W. Donnelley	do	J 11	1897	Bored, 2-inch	31	31	180	25	do			do	
1386	B. H. Norton	do	J 11	1897	Bored, 3-inch	31	31	185	24	do	64.75		do	Small.
1387	C. Doretv	Los Cerritos	I 11	1900	Bored, 4-inch	32	32	300		do	200.00		Irrigation	11
1388	do	do	I 11	1900	Bored, 2-inch	32	32	180		do	70.00			4
1389	W. M. Delano	Los Coyotes	K 11	1899	do	30	30	250		do			Domestic	†6
1390	J. T. McCann	do	J 11	1899	do	29	29	180	27	do			Domestic; irrigation.	
1391	do	do	J 11	1899	do	29	29	180	29	do			Irrigation	Small.
1392	J. S. McDonald	do	K 12	1899	do	28	28	550	27	do			Irrigation; domestic.	4
1393	A. Von Gruinegen	do	K 12	1885	Bored, 7-inch	28	28		26	do			Stock	Small.
1394	do	do	K 12	1898	Bored, 3-inch	28	28	550?	28	do			Irrigation	8
1395	do	do	K 12	1893?	Bored, 7-inch	28	28			do			do	1
1396	R. M. Foote	do	K 11	1876	do	28	28	236	27	do			Stock	Small.
1397	do	do	K 11	1885?	do	28	28	219	27	do			Domestic	Small.
1398	do	do	K 11	1899	Bored, 3-inch	28	28	501		do			Irrigation	3
1399	Francis Pearce	do	K 11	1876	Bored, 7-inch	30	30	275	28	Horsepower			do	
1400	do	do	K 11	1880	Bored, 4-inch	30	30	164		Artesian	240.00		do	
1401	M. Stanfield	do	K 11	1896	Bored, 2-inch	31	31	80	26	do			Domestic	Small.
1402	do	do	K 11	1896	do	31	31	300		do			Stock	Small.
1403	B. Chubbie	do	K 11	1885	Bored, 7-inch	32	32	200	26	do			Domestic	Small.
1404	F. E. Green	do	J 11	1898	Bored, 3-inch	34	34	175		do	70.00		Stock	Small.
1405	R. G. Ravenscroft	do	J 11	1892	Bored, 7-inch	33	33	130	25	Artesian, wind			Domestic; irrigation.	Small.
1406	do	do	K-11	1897	Bored, 3-inch	31	31	190		Artesian			Irrigation	3
1407	do	do	K-11	1897	Bored, 2-inch	31	31	190		do			do	2
1408	F. Hancock	do	J-11	1901	Bored, 3-inch	31	31	200		do			do	2
1409	J. H. Crittenden	do	J-11	1897	Bored, 2-inch	33	33	550	29	do	247.50		Domestic	
1410	Jim Mushrust	do	K-11	1893	Bored, 7-inch	33	33	180	24	do			do	Small.
1411	do	do	K-11	1899	Bored, 2-inch	35	35	350?	28	do			Irrigation	Small.
1412	Benj. Chubbie	do	K-11	1897	Bored, 3-inch	32	32	330	28	do	160.00		do	1
1413	Mrs. M. E. Frankle	do	K-11	1898	Bored, 2-inch, 30 feet; 3-inch, 270 feet.	32	32	300		do			do	Small.

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1414	Thos. Moyle	Los Coyotes	K-11	1895	Bored, 2-inch	33	33	181	24	Artesian	$100.00		Domestic; irrigation.	2
1415	R. W. Bingham	do	K-11	1899	do	34	34	190	27	do	100.00		Domestic	
1416	do	do	K-11	1892	Bored, 7-inch	34	34	237	22	do	575.00		Irrigation	7
1417	do	do	K-11	1899	Bored, 2½-inch	34	34	200		do	125.00		do	
1418	do	do	K-11	1899	do	34	34	200	27	do	125.00		do	Small.
1419	do	do	K-11	1900	Bored, 7-inch	34	34	295		do	675.00		do	7
1420	Judge Willis	do	K-11	1900	Bored, 2-inch	33	33	100?	27	do			Domestic	
1421	Geo. Apgar	do	K-11	1881	Bored, 7-inch	31	31	200	27	do	300.00		Stock	†1
1422	do	do	K-11	1897	Bored, 3-inch	32	32	165	27	do	85.00		Irrigation	9
1423	do	do	K-11	1897	Bored, 2-inch	32	32	235	27	do	125.00		do	3
1424	do	do	K-11	1891	Bored, 7-inch	34	34	316	26	do	435.00		do	1
1425	Perry Moore	do	L-11	1901	Bored, 3-inch	35	35	550	26	do			do	8
1426	Mrs. Hollister	do	L-11	1901	do	38	38	318	25	do	225.00		do	8
1427	M. Williams	do	L-11	1893	Bored, 7-inch	38	38	210	25	do	274.25		Domestic	Small.
1428	do	do	L-11	1900	Bored, 3-inch	38	38	318	26	do	225.00			8
1429	do	do	L-11	1900	do	37	37	320	26	do	225.00		Irrigation	5
1430	C. L. Chamberlain	do	L-11	1901	do	39	39	520		do	289.00		Stock	Small.
1431	O. J. Chamberlain	do	L-11	1903	Bored, 4-inch	41	41	286		do	268.00		Irrigation	25
1432	G. S. Chamberlain	do	L-11	1902	do	42	42	266	26	do	265.00		do	8
1433	E. A. Gotterba	do	L-11	1896	Bored, 2-inch	37	37	200+	27	do			Stock	Small.
1434	R. B. Luther	do	L-11	1902	do	38	38	87	28	do	75.00		Domestic; irrigation.	1
1435	C. Salisbury	do	M-11	1897	do	39	39	150	27	do			do	1

1436	W. Triplett	do	M-11	1897	Bored, 3-inch	45	45	600	26	do			Stock	Small.
1437	do	do	M-11	1897	do	45	45	600	27	do			do	Small.
1438	do	do	M-11	1891	Bored, 7-inch	45	45	200	27	do			do	Small.
1439	J. A. Campbell	do	M-11	1891	Bored, 4-inch	50	50	96		do			Not used	
1440	do	do	M-11	1900	Bored, 3-inch	50	50	250		do	84.00		Irrigation	
1441	do	do	M-11	1900	Bored, 2-inch	50	50	464	25	do	153.00		Domestic; irrigation.	
1442	J. W. Mann	do	M-11	1902	Bored, 4-inch	53	53	168	27	do	80.00		Irrigation	14
1443	Arch Stoddard	do	M-11	1902	Bored	54	54	240	28	do	140.00		do	2
1444	Mr. G. M. Hoard	do	N-11	1896	Bored, 2-inch	66	66	550	28	do			Stock	Small.
1445	Wm. McCarthy	do	N-11	1893	Driven, 1-inch	68	60?	100	25	Wind		$100.00	Domestic	
1446	W. Gusel	do	N-11	1902	Bored, 2-inch	67	57–	82	26	Hand			do	
1447	J. Mitchell	do	N-11	1895	Bored, 7-inch	67	61	450	27	Gas	1,000.00	600.00	Irrigation	48
1448	do	do	N-11	1897	do	67	61	250	27	do	300.00		do	
1449	Lyman & Niger	do	N-10,11	1888?	do	65	61	230	26	do			do	
1450	do	do	N-10,11	1902	Bored, 12-inch, 230 feet; 10-inch, 230 feet.	65	61	460	27	do	800.00		do	†150
1451	do	do	N-10	1901	Bored, 10-inch	65	61	100	27	do	166.00		do	
1452	do	do	N-10	1900	Bored, 7-inch	68	61	278		Wind	400.00		Domestic	
1453	E. A. Niger	do	N-10	1895?	Bored, 2-inch	70	67	300+	27	Hand			do	
1454	Mr. Shoemaker	do	N-10	1890?	Bored, 7-inch	69	67			do			Not used	
1455	J. W. McKenny	do	N-10	1891	Bored, 4-inch	66	66	320	26	Artesian			Stock; irrigation.	Small.
1456	R. C. Archibald	do	N-10	1901	do	65	65	120	26	Wind	35.00	100.00	Domestic	
1457	do	do	N-10	1895	Bored, 2-inch	64		422		Artesian	135.00		Not used	
1458	J. W. McKenny	do	N-10	1886	Bored, 7-inch	65	65	202		Artesian, hand			Domestic	Small.
1459	do	do	N-10	1897	Bored, 4-inch	65	65	407	26	Artesian	250.00		Irrigation	†1
1460	do	do	N-10	1903	Bored, 12-inch	65	65	400	27	do	900.00		do	
1461	do	do	N-10	1897	Bored, 2-inch	68	68	403		do	175.00		do	Small.
1462	Geo. E. Dutton	do	N-11	1891	Bored, 4-inch	62	58	275	25	Wind			Domestic	
1463	J. M. Robertson	do	N-10	1890	Bored, 7-inch	50	54	308	26	Hand	600.00		do	
1464	R. E. Ibbetson	do	N-10	1902	Bored, 10-inch	61	61	460	27	Gas	1,000.00	700.00	Irrigation	†80
1465	do	do	N-10	1895	Bored, 2-inch	61	61	460	28	Artesian			do	
1466	do	do	N-11		do	56	56		28	do			Stock	Small.
1467	Mr. Stone	do	N-11		Bored, 3-inch	57	57		26	do			do	Small.
1468	Isner & McCloud	do	N-10	1885	Bored, 7-inch	58	58		26	do			Domestic	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1469	Penelope Calder	Los Coyotes	N-10	1898	Bored, 3-inch	57	57	420	26	Artesian	$200.00		Stock	Small.
1470	do	do	N 10	1896	do	57	57	420		do	200.00		Not used	
1471	do	do	M 10	1898	do	53	53	420	29	do	200.00		Domestic	
1472	Dr. Jas. Calder	do	M 10	1898	do	52	25	420	28	do	200.00		do	
1473	do	do	N 10	1898	do	56	56	420		do	200.00		Not used	
1474	do	do	N 10	1898	do	51	51	420	29	do			do	
1475	Rev. J. Cameron	do	M 10		do	51	51	400?	32	do			Stock	Small.
1476	R. Loritt	do	M-10	1895	Bored, 2-inch	52	52	300	27	Wind			Domestic; stock	
1477	J. A. McDonald	do	M 10	1883	Bored, 7-inch	49	49	180	29	Artesian			Domestic	Small.
1478	do	do	M 10	1883?	do	51	51	200?		do			Stock	Small.
1479	do	do	M-10	1896	Bored, 3-inch	49	49	407	29	do	225.00		do	Small.
1480	do	do	M 10	1895	do	50	50	450	29	do	240.00		do	Small.
1481	do	do	M-10	1883	Bored, 7-inch	50	50			do			Not used	
1482	do	do	M 9	1902	Hydraulic, 3-inch.	51	51	197		do	100.00		Irrigation	3
1483	do	do	M 10	1902	do	50	50	237		do	125.00		do	2
1484	do	do	M-10	1902	Bored, 4-inch	50	50	230	30	do	150.00		do	1
1485	do	do	M 9	1883	Bored, 7-inch	56	56	250		do			Stock	1
1486	W. H. Hall	do	M-10	1902	Bored, 12-inch	45	45	286		Gas	550.00	$900.00	Irrigation	50
1487	do	do	M-10	1900	Bored, 7-inch	46	46	286		Artesian	250.00		Not used	
1488	do	do	L-10	1900	do	45	45	135	27	do	100.00		Domestic; irrigation.	6
1489	W. H. Forbes	do	L-11	1902	Hydraulic, 3-inch.	42	42	575	27	do	300.00		Irrigation	Small.
1490	do	do	L 11	1900	do	42	42	600	27	do	350.00		do	Small.
1491	do	do	L 11	1903	Hydraulic, 2-inch.	42	42	280	27	do	125.00		Domestic	1

1492	G. S. McWilliams	do	L-11	1898	Hydraulic, 3-inch.	42	42	393	28	do	210.00	Irrigation	3
1493	do	do	L-11	1898	do	43	43	280		do	128.00	do	2
1494	do	do	L-11	1896	Bored, 2-inch	43	43	280	27	do	125.00	Domestic	
1495	do	do	L-11	1897	Hydraulic, 3-inch.	43	43	378	27	do	208.00	Domestic; irrigation.	2
1496	do	do	L 11	1903	Bored, 4-inch	43	43	282	27	do	170.00	Irrigation	2
1497	M. C. Chase	do	L-11	1898	do	42	42	615	30	do	300.00	do	
1498	do	do	L 11	1902	Hydraulic, 3-inch.	42	42	280		do	168.00	do	3
1499	do	do	L 11	1903	Bored, 4-inch	42	42	280		do	196.00	do	4
1500	Mr. Haskell	do	L-10		Bored, 3-inch	44	44		26	do		do	Small.
1501	Mr. Shneck	do	L-10		Bored, 7-inch	43	43		29	do		Domestic; irrigation.	
1502	do	do	L 10		Hydraulic, 2-inch.	43	43			do		Not used	
1503	E. Heinmerte	do	L 10	1883	Bored, 6-inch	39	39	280	26	do	500.00	Domestic	Small.
1504	Mr. Omstead	do	L-10	1883	Bored, 7-inch	41	41	250	27	do		do	Small.
1505	J. W. Alexander	do	K-10	1892	Hydraulic, 2-inch.	41	41	235	23	do	150.00	Domestic; irrigation.	1
1506	do	do	K-10	1895	do	41	41	230	24	do	150.00	Domestic	Small.
1507	J. F. Thompson	do	K-10	1897	do	41	41	500	36	do		Domestic; irrigation.	2
1508	do	do	K-10	1898	do	41	41	500	32	do		Irrigation	3
1509	W. Hancock	do	K-10	1888?	Bored, 7-inch	41	40		23	Hand		Domestic	
1510	A. J. Wells	do	K-11	1888?	do	37	37	200	25	Artesian		do	Small.
1511	Carey & McKinley	do	K-11	1897	Hydraulic, 2-inch.	37	37	200	32	do		do	Small.
1512	do	do	K-11	1896	Bored, 7-inch	37	37	200	30	do		Irrigation	1
1513	do	do	K-11	1898	Hydraulic, 2-inch.	37	37	500	31	do		do	2
1514	do	do	K-11	1898	do	37	37	200		do		Not used	
1515	L. Thornton	do	J-11	1896	do	38	38	200		do	66.00	Domestic	
1516	do	do	J-11	1901	Bored, 5-inch	38	38	200		do	175.00	Irrigation	9
1517	do	do	K-11	1901	do	39	39	200	23	do		do	9
1518	A. S. Manefee	do	J-11	1893	Bored, 4-inch	38	38	200		Gas, artesian	430.00	Domestic; irrigation.	3
1519	John Severs	do	J-11	1885	Bored, 7-inch	38	38	189	22	Artesian	237.50	Domestic	12
1520	F. T. Morse	do	J-11	1892	do	37	37	243	23	do		Irrigation	19
1521	W. L. Campbell	do	J-11	1893	Hydraulic, 3-inch.	35	35	156	55	do		Domestic	
1522	do	do	J-11	1903	Bored, 7-inch	35	35	303	22	do	500.00	Irrigation	12
1523	W. A. Campbell	do	J-11	1875	do	39	39	203	22	do	650.00	Domestic	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1524	W. A. Campbell	Los Coyotes	J 11	1874	Bored, 7-inch	40	40	262	22	Artesian	$850.00		Domestic	Small.
1525	J. E. Courtney	do	J 11	1875?	do	42	42	180+	23	Wind, artesian			do	Small.
1526	John Keir	Los Cerritos	J 11	1883	do	40	40	228	23	Artesian			do	†1
1527	Mrs. M. Butler	do	J 11	1897	Hydraulic, 2-inch.	41	41	185		do			do	
1528	Mr. Gordon	Los Coyotes	J 11		do	43	43		23	do			Stock	Small.
1529	J. C. Smith	do	K 10	1897?	do	42	42		23	do			Domestic	Small.
1530	N. D. Robinson	do	K 10	1892	do	40	40	195	22	do	100.00		Stock	4
1531	do	do	K 10	1877	Bored, 7-inch	40	40	127	23	Hand, artesian.	150.00		Domestic	†2
1532	do	do	K 10	1894	Hydraulic, 3-inch.	39	39	185		Artesian	100.00		Irrigation; stock.	5
1533	Mr. Dolley	do	K 10	1897?	Hydraulic, 2-inch.	44	44	175	25	do			Not used	
1534	F. H. Purdy	do	K 10	1888?	Bored, 7-inch	42	42	180	23	do			Domestic; irrigation.	Small.
1535	do	do	K 10	1899	Hydraulic, 3-inch.	41	41	140		do			Irrigation	
1536	Mr. Hurley	do	K 10	1898	Hydraulic, 2-inch.	43	43	140	22	do			Domestic	
1537	C. Dohn	do	J 10	1888	Bored, 7-inch	42	42	200		do	300.00		do	
1538	do	do	K 10	1898	Hydraulic, 2-inch.	40	40	175	25	do	51.00		Irrigation	†2
1539	do	do	J 10	1897	do	42	42	175		do	51.00		Not used	
1540	B. A. Epperly	do	J 10	1897	Bored, 7-inch	44	44	200	22	do			Irrigation	
1541	do	do	J 10	1897	Hydraulic, 2-inch.	44	44	200	22	do			do	1
1542	Epperly estate	do	J 10	1895	do	42	42	560		do			Domestic; irrigation.	1
1543	do	do	J 10	1893?	Bored, 7-inch	42	42	300	22	do			Irrigation	Small.
1544	do	do	J 10	1896	Hydraulic, 2-inch.	40	40	250	22	do			Not used	
1545	do	do	J 10	1896	do	40	40	560	30	do			do	

1546	S. A. Frampton	do	J-10	1875?	Bored, 7-inch	42	42	200+	22	do			Domestic	12
1547	do	do	J-10	1891	do	40	40	200+	22	do			Irrigation	2
1548	L. Carse	do	J-10	1877	do	43	43	252		do	525.00		Stock	Small.
1549	do	do	J-10	1897	Hydraulic, 2-inch	43	43	142	25	do	50.00		Domestic	
1550	F. T. Morse	do	J-10, 11	1892	Bored, 7-inch	41	41	197	23	do			Domestic; irrigation	
1551	E. P. Morrison	do	J-10	1897	Hydraulic, 2-inch	44	44	176	23	do	55.00		Domestic	Small.
1552	Crown Creamery Co	do	J-10	1900	do	45	45	176	22	do			do	
1553	N. Gregory	do	I-10		Bored, 7-inch	46	46	464	22	do			do	Small.
1554	do	do	I-10		Hydraulic, 2½-inch	45	45	170	23	do			Irrigation	Small.
1555	Mr. Russell	do	I-10		Hydraulic, 2-inch	42	42		22	do			Domestic	Small.
1556	C. M. Buck	do	I-10	1899	Bored, 7-inch	45	45	180	22	do			do	Small.
1557	J. E. Stones	do	I-10	1902	Hydraulic, 3-inch	46	46		21	do			Domestic; irrigation	4
1558	Mr. White	do	I-10	1892?	Hydraulic, 2-inch	44	44		24	do			Stock	Small.
1559	L. C. Butler	do	I-10	1890	do	46	46	113	25	do			Domestic	Small.
1560	W. A. Sackett	Los Cerritos	I-10	1891	do	45	45	180	25	do			Domestic; irrigation	2
1561	J. W. Hansard	do	H-1	1897	do	42	42	180	26	do			Stock	Small.
1562	Mrs. Richardson	do	H-11		do	43	43	180	25	Hand, artesian			Domestic	Small.
1563	Alexander Watson	do	H-10	1895	do	45	45	160	26	do			Domestic; irrigation	
1564	Mr. Burger	do	H-10	1897	do	47	47	250	22	Artesian	85.00		Domestic	Small.
1565	N. Jish	do	H-10	1899	do	47	47	633	22	do	300.00		Irrigation	
1566	J. A. Goodlin	do	H-10	1893	do	47	47	131	28	do	36.00		Domestic; irrigation	Small.
1567	S. E. Garber	do	H-10	1896	Bored, 7-inch	50	50	600+	27	Wind, artesian	1,000.00		Irrigation	
1568	do	do	H-10	1902	Bored, 12-inch	50	46	130		Not raised	200.00		Not used	
1569	S. T. Carum	do	H-10	1895	Hydraulic, 2-inch	50	50	180	25	Wind, artesian	80.00		Domestic	Small.
1570	H. W. Carum	do	I-10	1890	Bored, 7-inch	48	46	190	25	Hand	280.00		Stock	
1571	do	do	I-10	1900	Bored, 3½-inch	48	47	135		do	115.00		Domestic	
1572	do	do	I-10	1900	do	48	47	133		Not raised	115.00		Not used	
1573	W. L. Campbell	Los Coyotes	I-10	1886	Bored, 4-inch	49	49	160	27	Artesian			Stock	Small.
1574	do	do	I-10	1895	Bored, 7-inch	49	49	150	27	do			do	Small.
1575	do	do	I-10	1893	Hydraulic, 2-inch	50	50	150	22	do			Domestic	Small.
1576	do	do	I-10	1893	do	50	50	150	26	do			Stock	Small.
1577	do	do	I-9, 10	1886	Bored, 7-inch	51	51	160		do			do	Small.

Wells in the Downey quadrangle Continued.

Number of well.	Owner.	Location.	Map location	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Yields per 100,000	Method of lift.	Cost of well.	Cost of machinery	Use of water	Quantity of water
						Feet.	*Feet.*	*Feet.*						Miner's inches
1578	L. E. Dean	Los Coyotes	I 10		Bored, 7-inch	51	51	215	23	Hand, artesian			Domestic	
1579	J. B. Ashley	do	I 10	1898	do	51	51	278	23	Artesian			Domestic, irrigation	1
1580	I. L. de Cereq	do	I 10	1900	Hydraulic, 2-inch	50	50	78		do	$35 00		Domestic	Small
1581	John Paull	do	I 10	1879	Bored, 7 inch	49	49	300	23	Hand, artesian			do	Small
1582	D. C. Ewing	do	I 10		do	48	48		22	do			do	
1583	P. T. Ward	do	I 10	1880?	do	47	47	300	22	Artesian			do	Small
1584	E. P. Meggs	do	I 10	1901?	Driven, 1¼ inch	47	47	70	22	Hand			do	
1585	C. C. Wright	do	I 10	1895	Hydraulic, 3 inch	53	53	330	22	Artesian			do	Small
1586	John Brooker	do	I 10	1895	Hydraulic, 2-inch	52	52	100	23	Hand, artesian			do	
1587	S. R. Ibbotson	do	I 10	1894	do	52	52	176		Artesian	100 00		do	
1588	Artesian school district	do	I 10	1886	Bored, 4-inch	47	47	300		do			do	
1589	Artesian Christian Church	do	I 10	1893	Hydraulic, 2-inch	48	48	127	23	do			do	Small
1590	Wm. Gamble	do	I 10	1900	do	52	52	85	24	do			do	Small
1591	do	do	J 10	1893?	Bored, 6-inch	51	51	300		do			Irrigation	
1592	M. E. Rurviance	do	J 10	1888?	Bored, 4-inch	50	50	125	24	do			Domestic	Small
1593	Methodist Episcopal parsonage	do	J 10		Hydraulic, 2-inch	47	47		23	do			Domestic, irrigation	1
1594	C. B. Scott	do	J 10	1893?	Bored, 7-inch	46	46	333	22	do			Domestic	
1595	G. R. Frampton	do	J 10	1883	do	45	45		23	do			do	
1596	W. H. Smith	do	J 10	1896	Hydraulic, 2-inch	45	45	212	22	do			Not used	
1597	L. J. Stone	do	J 10	1893	do	45	45	181	23	Hand, artesian	125 75		Domestic	Small
1598	Mr. Morris	do	J 10	1888?	Bored, 8-inch	44	44	300	23	Artesian			do	Small

1599	I. Nicholls	do	J-10	1888?	Bored, 7-inch	43	43	225		do			Stock	
1600	do	do	J-10	1900	Hydraulic, 3-inch.	43	43	531	23	do	300.00		Irrigation; domestic.	Small.
1601	G. R. Frampton	do	J-10	1900	Hydraulic, 2-inch.	47	47	267	22	do	120.00		Domestic	
1602	C. A. Linge	do	J-10	1894?	do	48	48	248	21	do			do	Small.
1603	James Gillespie	do	J-10	1892	Bored, 7-inch	48	48	220	22	do	350.00		do	
1604	do	do	K-10	1900	Hydraulic, 2-inch.	58	58	190	23	do	91.00		do	
1605	do	do	J 9	1895	Hydraulic, 3-inch.	44	44	268	33	Hand, artesian			do	Small.
1606	Mrs. J Purdy	do	J-10	1895	Hydraulic, 2-inch.	49	49	140	23	Artesian			do	
1607	do	do	J-10	1896	do	49	49	150	23	do			do	
1608	H D. Andrews	do	J-10	1897	do	50	50	130	23	do			do	1
1609	T. H. Johnson	do	J-9	1896	do	50	50	240	22	do			do	
1610	do	do	J-9	1896	Hydraulic, 3-inch.	50	50	190	23	do			Irrigation	Small.
1611	R Carter	do	J-10	1896	Hydraulic, 2-inch.	50	50		23	do			Domestic	
1612	Mrs. M. Turner	do	J 9	1895	do	51	51	150		Wind, artesian		$150.00	do	
1614	D. S Drisbach	do	J-10	1894	do	47	47	190	23	Gas, artesian	125.00	300.00	Irrigation	10
1615	T. P. Patterson	do	J 10	1896	do	48	48	150	24	Artesian	50.00		Domestic	
1616	do	do	J-10	1899	Bored, 4-inch	48	48	130		do	130.00		Not used	
1617	J. B Hollingsworth	do	J 10	1898	Hydraulic, 2-inch.	47	47	150	24	do	45.00		Domestic	
1618	S. G. Woodward	do	J-10	1895	Bored, 7-inch	46	46	300		do	300.00		Irrigation	Small.
1619	do	do	K-10	1899	Hydraulic, 3-inch.	47	47	151	26	Wind, artesian	47.00		Domestic; irrigation.	Small.
1620	Mr. Gould	do	K-10	1898	Hydraulic, 2-inch.	46	46	600		Artesian			Not used	
1621	D. Thatcher	do	K-10	1893	Bored, 2-inch	48	48	154	26	do	100.00		Domestic	Small.
1622	Mrs Meador	do	K-10		Bored, 7-inch	47	47	500+	24	do			do	
1623	Mrs. M. E. Thomas	do	K-10	1890?	do	47	47	200 +		Hand			do	
1624	Mrs. Ella Pierce	do	K-10	1885?	do	44	44	260?	23	Artesian, hand			do	Small.
1625	J. F. Smith	do	K-10	1893	do	47	47	125	23	Artesian	250.00		Domestic; irrigation.	
1626	A. M. Costner	do	K-10	1899	Bored, 2-inch	47	47	217	28	do	72.00		Domestic	Small.
1627	J. A. Smith	do	L-10	1893	Bored, 6-inch	48	48	170	25	do	200.00		Irrigation	8
1628	J. B. Alexander	do	L-10	1885	Bored, 7-inch	50	50	336	28	do	500.00		Domestic	1
1629	Mr. Johnson	do	K-10		Bored, 2-inch	43	43		32	do			Irrigation	1
1630	do	do	K-10		do	42	42		36	do			do	Small.
1631	H. D. Andrews	do	K-10	1901	Bored, 3-inch	42	42		30	do	150.00		do	2
1632	J. A. Smith	do	L-10	1883	Bored, 4-inch	47	47	124		do	100.00		Stock	Small.

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1633	J. A Smith	Los Coyotes	L-10	1893	Bored, 6-inch	48	48	200	....	Artesian	$300.00		Irrigation	4
1634	Sullivan estate	do	L-10	1895	Bored, 3-inch	48	48	300	28	do			Not used	
1635	do	do	L 10	1901	do	47	47	280	45	do	160.00		Irrigation	12
1636	J B Monroe	do	L 10	1898	do			137	27	do			do	3
1637	do	do	L 10	1898	do	47	47	145	27	do	79.75		do	1
1638	do	do	L 9	1885	Bored, 7-inch	52	52	145	27	do	150.00		Domestic	Small.
1639	Mr Pug Rhodes	do	L-10	1901?	Bored, 4-inch	48	48	140	26	do			do	Small
1640	J B Teel	do	L 10	1897	Bored, 2-inch	48	48	200	27	do	60.00		Domestic; irrigation	
1641	do	do	L 10	1895	do	48	48	140	28	do			Stock	Small.
1642	do	do	L 10	1895	Bored, 3-inch	46	46	600	35	do			Irrigation	Small
1643	Mr Zeus	do	M 10	1895?	Bored 2-inch	49	49	170	28	do			do	4
1644	R G French	do	L 10	1897	do	49	49	140	27	do	37.50		Domestic	Small.
1645	do	do	L 10	1888	Bored, 4-inch	49	49	140	26	do	160.00		Irrigation	1
1646	do	do	L 10	1897	Bored, 2-inch	49	49	140	27	do	37.50		Domestic	Small.
1647	W E Dorety	do	L 9	1878	Bored, 7-inch			150	28	do			do	Small.
1648	J R. Mitchell	do	M 9	1901	Bored, 3-inch	52	52		27	do			Irrigation	6
1649	do	do	M-10		Bored, 2-inch	51	51			do			do	4
1650	C. A. Hudgins	do	L-9	1891	do	58	58	90?	....	Hand, artesian			Domestic	
1651	do	do	L-9	1897?	do	57	57	335	51	Artesian			Stock	2
1652	Dr. Crandall	do	L-9	1888	Bored, 7-inch	56	56	130	27	do			do	Small.
1653	T. M. Dillman	do	L-9	1893	Bored, 2-inch	54	54	108	25	Hand	65.00		Domestic	
1654	John Baker	do	L 9	1885?	Bored, 7-inch	56	56	114	....	Artesian			Stock	Small.
1655	A. L. Smith	do	L-9	1899	Bored, 2-inch	57	57	103	25	do	50.00		Domestic; stock	

1656	G. H. Lillard	do	L-9	1884	Bored, 7-inch	45	45	150	30	Artesian, hand			Domestic	Small.
1657	do	do	L-9	1894?	Bored, 2-inch	45	45	605	24	Artesian			Irrigation	4
1658	Mrs. M. E. Robbins	do	L-10	1883?	Bored, 4-inch	51	51	330?	26	do			Domestic	Small.
1659	D. H. Lillard	do	L-9	1893	Bored, 2-inch	57	57	496	21	do			Domestic; irrigation.	4
1660	do	do	L-9	1883	Bored, 7-inch	59	59	385	52	do	1,000.00		Stock	Small.
1661	J. L. Dougherty	do	L-10	1891	Bored, 2-inch	51	51	485		do	240.00		Irrigation	4
1662	do	do	L-9, 10	1891	do	52	52	485	40	do	242.50		Domestic	Small.
1663	do	do	L-9	1903	do	54	52	125		do	50.00		Stock	
1664	C. W. Clanton	do	L-9	1888	Bored, 7-inch	60	60	180	22	do			Domestic	Small.
1665	do	do	L-9	1897	Bored, 2-inch	67	67	365	39	do	150.00		Stock	Small.
1666	P. H. Vedder	do	K-9	1897	do	60	60	130	22	do	130.00		Domestic	2
1667	James A. Smith	do	K-9	1877	Bored, 7-inch	53	53	293	23	do			Domestic; irrigation.	1
1668	John Masten	do	K-9	1888	do	59	59	160	22	do			Domestic	Small.
1669	do	do	K-9	1895	Bored, 2-inch	59	59	415	32	do			Irrigation	Small.
1670	do	do	K-9	1895	do	60	60	420	33	do			do	1
1671	Chas. Grimm	do	K-9	1898	do	58	58	467	19	do	250.00		do	5
1672	J. A. Smith	do	K-9	1876	Bored, 7-inch	53	53	350	22	do	1,000.00+		Domestic	Small.
1673	do	do	K-9	1891	do	53	53	558	22	do	1,000.00		Stock	Small.
1674	M. E. Purdy	do	K-9	1896	do	51	51		26	do			do	Small.
1675	Mr M. H. Meyers	do	K-10	1894	Bored, 2-inch	48	48	135	27	Hand, artesian			Domestic	Small.
1676	J. Swagard	do	K-9	1898	do	53	53	140	27	Artesian			do	Small.
1677	L. C. Misom	do	K-9	1893	do	54	54	185	25	Artesian, hand	65.00		Domestic; irrigation.	Small.
1678	F. M. McCreary	do	K-9	1893?	do	54	54	145	23	Artesian			Domestic	Small.
1679	do	do	K-9	1903	Bored, 4-inch	53	53	145		Gas, artesian	106.00	$400.00	Irrigation	†35
1680	C. A. Abbott	do	J-9	1902	Bored, 2-inch	51	51	70	22	Artesian	70.00		Domestic	Small.
1681	M. C. Porter	do	J, K-9	1897	Bored, 3-inch	50	50	130		do	65.00		Domestic	Small.
1682	J. W. Bell	do	J-9	1895	Bored, 2-inch	52	52	550	23	do			Stock	Small.
1683	do	do	J-9	1895	do	53	53	500?	20	do			do	Small.
1684	J. B. Benham	do	J-9	1897	do	54	54	600?	22	do			Domestic	Small.
1685	G. H. Clark	do	J-9	1899	do	54	54	600		do			Irrigation	Small.
1686	do	do	J-9	1888?	Bored, 7-inch	54	54	200	23	do			Domestic	
1687	John Gillispie	do	J-9	1897	Bored, 2-inch	53	53	140+		do	60.00		do	
1688	Mrs. Matthews	do	J-9	1895?	do	56	56		24	do			do	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1689	F. M. Schnabel	Los Coyotes	J-9	1900?	Bored, 2-inch	58	58	130	24	Artesian	$75.00		Domestic; irrigation.	
1690	Mr. Holingsworth	do	I-9		do	58	58		21	do			Not used	
1691	R. E. Dolley	do	I-9	1888?	Bored, 7-inch	57	57	230?	25	do	500.00		Domestic	Small.
1692	do	do	I-9		Bored, 2-inch	56	56	570	24	do			Irrigation	Small.
1693	M. L. Black	do	J 9		do	53	53		23	do			Domestic	Small.
1694	E. J. Collins	do	I-10	1873?	Bored, 7-inch				25	Hand			do	
1695	Frank Seppi	do	I-9		Bored, 2-inch	58	58		26	Artesian			do	Small.
1696	L. M. Moore	do	I 9	1897	do	58	57	156	26	Hand			do	
1697	do	do	I 9	1899	do	57	57	588		Artesian			Irrigation	Small.
1698	Frank Seppi	do	I 9	1898	Bored, 4-inch	64	64	495		do			do	
1699	A. W. Ellis	do	I 9	1891	Bored, 2-inch	57	56	220	23	Hand			Domestic	
1700	Artesia graveyard	do	I-9	1880?	Bored, 7-inch	56	53	190	25	Wind			Irrigation	
1701	S. T. Corum	do	I-9	1880	Bored, 2-inch	54	54	200	28	Artesian			Domestic	Small.
1702	J. Hay	do	I-9		Bored, 7-inch	53	53			do			Stock	Small.
1703	C. D. Thompson	do	I-9	1894?	do	56	56	121	26	Artesian, hand			Domestic	Small.
1704	Mr. McFarland	do	H-10	1888?	Bored, 4-inch	53	53	140	30	Hand			do	
1705	do	do	H-10	1901	Bored, 3-inch	53	53	600	23	Artesian			Irrigation	3
1706	John Zinn	Los Cerritos	H-10	1880?	Bored, 4-inch	52	52	144		do			Stock	Small.
1707	G. A. Brown	do	H-9	1895	Bored, 2-inch	56	56	128	30	Wind			Domestic	
1708	Jacob P. Thompson	do	H-9	1878?	Bored, 7-inch	55	55	120	31	do	800.00		do	Small.
1709	do	do	H-9	1884	Bored, 4-inch	56	55	128			108.00		Not used	
1710	W. T. Gann	do	H-9	1898	Bored, 2-inch			608	23	Artesian	350.00		Domestic	Small.

1711	.....do.....	.....do.....	H-9.....	1888?	.....do.....	57	.....	130	31	Hand.....	.....	.....	.....do.....	.....
1712	Page estate.....	Los Coyotes.....	I-8.....	.....	.....do.....	.....	.....	.....	34	.....do.....	.....	.....	.....do.....	.....
1713	S. T. Corum.....	.....do.....	H-8.....	1878	Bored, 7-inch.....	65	65	111	....	Artesian.....	.....	.....	Stock.....	.....
1714	H. Vogt.....	.....do.....	I-8.....	1898?	Bored, 2-inch.....	68	68	.....	34	Hand, artesian.....	.....	.....	Domestic.....	.....
1715	S. Holgate.....	.....do.....	I-8.....	.....	Bored, 7-inch.....	.....	.....	104	33	.....do.....	.....	.....	.....do.....	.....
1716	S. Washburn.....	.....do.....	I-8.....	1891	.....do.....	65	59	177	32	.....do.....	.....	.....	.....do.....	.....
1717	Chas. Young.....	.....do.....	I-9.....	1900	Bored, 3-inch.....	63	63	120	....	Wind, artesian.	66.00	$150.00	.....do.....	.....
1718	W. Dolly.....	.....do.....	I-9.....	1875?	Bored, 7-inch.....	.....	.....	277	26	.....do.....	.....	.....	.....do.....	.....
1719	.....do.....	.....do.....	I-9.....	1898	Bored, 4-inch.....	.....	.....	133	....	Artesian.....	.....	.....	Stock.....	.....
1720	O. D. Thompson.....	.....do.....	I-9.....	1902	Bored, 2-inch.....	.....	.....	200	29	Wind.....	50.00	200.00	Domestic.....	.....
1721	.....do.....	.....do.....	I-9.....	1875?	Bored, 7-inch.....	61	61	200	....	Artesian, hand.	.....	.....	Stock.....	.....
1722	.....do.....	.....do.....	I-8.....	1878?	.....do.....	66	65	200	....	Artesian.....	.....	.....	.....do.....	.....
1723	J. Vance.....	.....do.....	I-9.....	1878	.....do.....	59	58	200	32	Hand.....	.....	.....	Domestic.....	.....
1724	J. F. Brown.....	.....do.....	I-9.....	1897	Bored, 2-inch.....	64	64	150	....	Artesian, wind.	.....	160.00	.....do.....	Small.
1725	Mr. McKinney.....	.....do.....	I-9.....	1902	Bored, 3-inch.....	62	62	158	25	Artesian.....	}	.....	.....do.....	8
1726	.....do.....	.....do.....	I-9.....	1902	.....do.....	52	52	116	26	.....do.....	200.00	.....	Stock.....	.....
1727	.....do.....	.....do.....	I-9.....	1903	.....do.....	64	64	135	27	.....do.....	.....	.....	Irrigation.....	8
1728	.....do.....	.....do.....	I-9.....	1898	.....do.....	64	64	485	.....	.....do.....	175.00	.....	.....do.....	5
1729	Mr. Copeland.....	.....do.....	I-9.....	.....	Bored, 2-inch.....	65	65	130	33	.....do.....	.....	.....	Domestic; irrigation.	Small.
1730	H. W. White.....	.....do.....	J-9.....	1903	.....do.....	64	64	125?	26	.....do.....	.....	.....	Domestic.....	Small.
1731	W. L. Coward.....	.....do.....	J-9.....	1900	Bored, 4-inch.....	62	62	190	23	.....do.....	80.00	.....	Stock; irrigation.	1
1732	.....do.....	.....do.....	J-9.....	1884	.....do.....	62	62	190	23	.....do.....	125.00	.....	Domestic.....	1
1733	Frank Gillespie.....	.....do.....	J-9.....	1887	Bored, 7-inch.....	57	57	200	24	.....do.....	.....	.....	.....do.....	.....
1734	W. H. Matthews.....	.....do.....	J-9.....	1895?	Bored, 2-inch.....	51	51	86	22	.....do.....	86.00	.....	Domestic; irrigation.	Small.
1735	Chas. West.....	.....do.....	J-9.....	.....	.....do.....	56	56	.....	.....	.....do.....	.....	.....	Irrigation.....	Small.
1736	.....do.....	.....do.....	J-9.....	.....	.....do.....	55	55	.....	25	.....do.....	.....	.....	Domestic.....	.....
1737	Chas. Young.....	.....do.....	J-10.....	1900	Bored, 3-inch.....	51	51	192	24	.....do.....	.....	.....	Irrigation.....	Small.
1738	Frank Leeper.....	.....do.....	J-8.....	1878?	Bored, 7-inch.....	65	65	163	24	Wind.....	.....	.....	Domestic; irrigation.	Small.
1739	.....do.....	.....do.....	J-8.....	1902	Bored, 2-inch.....	66	66	117	24	Artesian.....	35.00	.....	Stock.....	†1
1740	F. W. Hackney.....	.....do.....	J-8.....	.....	Bored, 7-inch.....	69	69	136	24	Wind.....	.....	.....	Domestic.....	.....
1741	.....do.....	.....do.....	J-8.....	.....	Bored, 2-inch.....	59	59	123	....	Artesian.....	.....	.....	Irrigation.....	Small.
1742	J. W. Donovan.....	.....do.....	J-8.....	1888?	Bored, 4-inch.....	69	69	132	25	Horsepower, artesian.	.....	.....	Domestic; irrigation.	Small.

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1743	J. W. Donovan	Los Coyotes	J 8	1895?	Bored, 2-inch			140?		Artesian			Stock	Small.
1744	McKinney & Searight	do	J 8	1885	Bored, 7-inch	72	70	150	23	Hand			Domestic	
1745	Mrs. A. M. Sproule	do	I, J 8	1878	do	70		130	24	Artesian			Irrigation	Small
1746	do	do	J 8	1899	Bored, 3-inch	67	67			do			do	3
1747	do	do	I 8	1886	Bored, 2 inch	69	69	137	32	do	$48.00		Domestic	Small.
1748	W. L. Coward	do	J 9	1899	Bored, 3-inch			190	24	do	80.00		Irrigation	8
1749	H. Gotterba	do	I 8	1886	Bored, 2-inch	68	68	240	33	Artesian, hand			Domestic	Small.
1750	W. C. Sproul	do	I 8	1875	Bored, 7-inch	69	69	200?	31	Hand, artesian			do	
1751	do	do	I 8	1895	Bored, 2-inch	70	70	450	23	Artesian	120.00		Domestic; irrigation.	Small.
1752	C. G. Bremond	do	I 8	1889	Bored, 4-inch	70	70	133	33	Hand, artesian	110.00		do	
1753	D. J. Buehn	do	I 8	1876	Bored, 7-inch	68	68	185		Wind, artesian	700.00	$450.00	Domestic	
1754	Perris Moore	do	I 8	1903	Bored, 3-inch			172	31	Hand			do	
1755	J. S. Eliot	do	I 8	1893	Bored, 2-inch	76	75	150	37	do	90.00		do	
1756	Newriver school district.	do	I 7	1898	do	83	82	105	42	do			do	
1757	W. P. Tibbett	do	I 7	1883?	Bored, 4-inch	81	81	120		Hand, artesian			do	
1758	John McLawton	do	I 7	1900	do	80	80	126	37	Artesian			Stock	Small.
1759	Mrs. Stienhart	do	I 8	1878?	Bored, 6-inch	51	51	120?	29	do			do	Small.
1760	Robert Sackett	Los Cerritos	H 8	1902	Bored, 12-inch	68	68	104		Gas	165.00		Irrigation	60
1761	do	do	H 8	1900	Bored, 2-inch	64	64	100		Hand, artesian	80.00		Domestic	
1762	M. H. Holland	Los Coyotes	I 8	1884	Bored, 7-inch	73	73	130		Steam, artesian			Irrigation	Small.
1763	W. B. Pendleton estate	Los Cerritos	H 8	1885	do	63	63	150	31	Artesian			Not used	
1764	John McLawton	Los Coyotes	H 7	1888	Bored, 4-inch	77	77	120	41	Hand			Domestic	

1765	Steve Strong	do	I-8		Bored, 2-inch	77	76	107		Wind			Stock		
1766	do	do	I-7		do	82	81	110?	43	do			Domestic		
1767	S. Washburn	do	I-7	1885?	Bored, 4-inch	83	81	100?	31	Gas		125.00	do		Small.
1768	E. Clark	do	I-8		Bored, 2-inch	76	76	130?	32	Artesian			Stock		Small.
1769	Frank Coulon	do	I-7	1896	do	83	82	100?		do			do		
1770	do	do	I-7	1883?	Bored, 3-inch	85	83	100	34	Wind		117.00	Domestic		
1771	Mr. Thorn	do	I-7	1883?	Bored, 7-inch	88	85	175		Hand, gas			Domestic; irrigation.		
1772	Mrs. Strong	do	I-7		Bored, 2-inch	83	83		22	Artesian			Stock; irrigation.		Small.
1773	David Bullis	do	J-7	1903	do	86		110		Hand	40.00		Domestic		
1774	Mrs. C. Burmiller Hickey.	do	J-8	1885	Bored, 7-inch	81	81	435	21	Wind	1,400.00		do		
1775	Mr. Swagard	do	J-8	1890?	Bored, 2-inch	76		150	29	Hand			do		
1776	Geo. Heberle	do	J-8		Bored, 7-inch	81	67	80?	42	do			do		
1777	W. F. Williamson	do	J-8	1883?	do	69	69	140?	27	Artesian			do		Small.
1778	do	do	J-8		do	70	70	127	29	do			Stock		Small.
1779	C. Nottingham	do	J-8	1878	do	68	68	200	26	do			do		Small.
1780	Mrs. M. Evans	do	J-8	1885	do	67	67	180	26	do			do		1
1781	A. Nottingham	do	K-8	1901	Bored, 2-inch	69	69	762		do	350.00		Irrigation		
1782	do	do	K-8	1895	do	70	70	386	22	do	125.00		Not used		
1783	W. M. Allison	do	J-9	1885	Bored, 7-inch	62	62	260	23	Wind, artesian	500.00		Domestic		
1784	do	do	J-9	1898	Bored, 3-inch	62	62	416	22	Artesian	200.00		Stock		Small.
1785	do	do	J-9	1873	Bored, 7-inch	62	61	150					Not used		
1786	Mrs. James	do	K-9		do	61	61	150	29	Hand			Domestic		
1787	Mr. Porter	do	J-9	1880?	do	58	58	400?	29	Artesian, wind			Domestic; stock.		Small.
1788	H. F. Drake	do	J-9	1902	Bored, 2-inch	60	60	629	20	Artesian	200.00		Irrigation		4
1789	John Aultman	do	K-9	1894	do	58	58	190		do			Domestic		
1790	Joe Clanton	do	K-9	1895	Bored, 7-inch	57	57	190	26	do			do		
1791	J. F. Weaver	do	K-9	1898	Bored, 2-inch	56	56	612	20	do	350.00		Irrigation; domestic.		5
1792	H. F. Drake	do	K-9	1893	Bored, 7-inch	62	62	429	21	do	1,000.00		Stock		Small.
1793	do	do	K-9	1880	do	62	62	200	23	Artesian, wind			Domestic		Small.
1794	Mr. McGentis	do	K-9	1875	do	64	64	130	27	Hand			do		
1795	J. G. Denman	do	K-9	1898	do	65	65	160	22	Wind, artesian	250.00		do		
1796	do	do	K-9	1899	Bored, 2-inch	65	65	400	20	Artesian	200.00		Stock		Small.
1797	do	do	K-9	1874	Bored, 7-inch	68	67	312	24	Gas	250.00	400.00	Irrigation		

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1798	J. G. Denman	Los Coyotes	K-9	1899	Bored, 2-inch	68	68	408	21	Artesian	$200.00+		Irrigation	Small.
1799	do	do	K-9	1898	Bored, 3-inch	68	68	379	20	do	200.00+		Irrigation; stock	Small.
1800	do	do	K-9	1888	Bored, 7-inch	67	67	130		Wind, artesian	140.00		Stock	
1801	J. W. Clanton	do	K-9	1896	Bored, 2-inch	66	66	155	25	do	60.00	$190.00	Domestic	Small.
1802	do	do	K-9	1896	do	66	66	365	21	Artesian	200.00		Stock	Small.
1803	do	do	K-9	1896	do	66	66	385	20	do			do	Small.
1804	J. W. Fowler	do	K-8	1894	do	67	67	400	20	do	225.00		Domestic	Small.
1805	do	do	K-8	1895	Bored, 3-inch	67	67	385		do	300.00		Not used	
1806	Mr. Brooks	do	K-8	1883	Bored, 7-inch	68	68	175	27	Artesian, hand			Domestic; stock	Small.
1807	C. Nottingham	do	K-8	1878?	do	73	73	175	27	Wind		300.00	Domestic	
1808	do	do	K-8	1897	Bored, 2-inch	71	71	719		Artesian	275.00		Irrigation	5
1809	do	do	K-8	1895	do	71	71	160	22	Wind, artesian	70.00		Irrigation; stock	Small
1810	J. L. Davee	do	K-8	1883	Bored, 6-inch	73	70	200?	31	Hand			Domestic	
1811	Jeff. Elliott	do	K-8		Bored, 2-inch	71	69	75	33	do			do	
1812	do	do	K-8		do	72	72	580	21	do			Irrigation	Small.
1813	do	do	K-8		do	72	72	580		do			do	4
1814	M. Noble	do	K-8	1899	do	77	77	691	22	do	271.00		do	
1815	do	do	K-8	1893	Bored, 7-inch	77	77	490	20	do	1,100.00		Domestic; stock	†2
1816	do	do	K-8	1902	Bored, 2-inch	77	77	491	20	do	240.00		Stock	†4
1817	J. T. Hallett	do	K-8	1894	do	73	73	300	21	do			Domestic	Small.
1818	do	do	K-8	1885	Bored, 7-inch	73		100		do	100.00		do	
1819	Theo Gillette	do	L-8	1893?	Bored, 2-inch	70	70	300?	21	Artesian, hand			do	Small.
1820	J. A. Smith	do	K-8	1895	do	65	65	150	26	Artesian			do	Small.

1821	Augustus F. Sproul	do	K-9	1877	Bored, 7-inch	62	62	200	28	do	800.00		Domestic; irrigation.	2
1822	do	do	K-9	1897	Bored, 2-inch	64	64	385	21	do	225.00		Stock	Small.
1823	J. H. Gwin	do	K-9	1900?	do	64	64	150	23	do			Domestic	Small.
1824	C. Grimm	do	K-9	1900	do	62	62	422	27	do	127.00		do	Small.
1825	do	do	K-9	1901	do	62	62	75		do	55.00		Stock	Small.
1826	W. Ramp	do	K-9	1897	do	66	66	150		do			Domestic; irrigation.	Small.
1827	Simon Stiffler	do	K-9	1891	do	64	64	100	27	do			Domestic	Small.
1828	T. L. Hungerford	do	L-9	1894	Bored, 4-inch	65	65	100	27	do			Domestic; irrigation.	Small.
1829	do	do	L 9	1899	Bored, 2-inch	63	63	80	29	do			Stock	Small.
1830	do	do	L-9	1894	do	65	65	100?	26	do			Irrigation	Small.
1831	Mrs. Law	do	L 9	1885?	Bored, 4-inch	61	60		25	Hand			Domestic	
1832	James Wilson	do	L-9	1898	Bored, 2-inch	62	62	362	46	Artesian	150.00		Domestic; irrigation.	Small.
1833	Carmenita School	do	L-9	1895	do	67	67	365	48	do	165.00		Domestic	Small.
1834	H. H. Hungerford	do	L-9	1891	Bored, 4-inch	67	67	104	29	Hand	78.00		do	
1835	John Aten	do	L-9	1899	Bored, 2-inch	65	65	300?	25	do	100.00		Domestic; irrigation.	
1836	Mr. Branscom	do	L-9		Bored, 3-inch	64	64		24	do			Irrigation	Small.
1837	do	do	L-9		Bored, 2-inch	64	64			Artesian			do	
1838	S. E. Samuel	do	L-8	1900	Bored, 3-inch	69	69	380	24	do	260.00+		do	
1839	do	do	L-8	1895	Bored, 2-inch	70	70	200	40	Hand	140.00		Domestic	
1840	J. R. Mitchell	do	L 9	1897	do	65	65	265	47	Artesian			Domestic; irrigation.	Small.
1841	B. L. Hutchins	do	L-9	1897	Bored, 3-inch	61	61	400	31	do			do	Small.
1842	do	do	L-9	1889	Bored, 7-inch			80		do			Stock	Small.
1843	J. R. Morrell	do	L-9	1896	Bored, 2-inch	61	61	344	53	do	100.00–		Domestic; stock.	Small.
1845	Wm. Marriott	Los Cerritos	F-10	1899	do	57	57	661	32	do	200.00		Domestic; irrigation.	2
1846	L. B. Bronson	do	F-10	1903	Bored, 4-inch	57	57	111	23	do	100.00		Domestic	Small.
1847	W. Willard	do	E-10	1903	Bored, 7-inch	59	56	100	23	Not installed	50.00		Not used	
1848	do	do	E-10	1903	Bored, 4-inch	59	56	77			65.45		do	
1849	do	do	E, F-10	1903	Bored, 2-inch	58	56	90	25	Hand			Domestic	
1850	F. A. Bronson	do	F-10	1902	do	59	60	135	23	Gas, artesian	*500.00		Irrigation	
1851	do	do	F-10	1807	do	59	59	341	28	Artesian	110.00		Domestic; irrigation.	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1852	J. B. Bean	Los Coyotes	E-10	1888?	Bored, 4-inch	60	60	640	....	Artesian	.....	.....	Domestic	Small.
1853	H. W. McKelry	....do	E-9	.....	Bored, 2-inch	60	60	400	24	....do	.....	.....	....do	.....
1854	....do	....do	F-9, 10	.....	....do	60	60	400	27	....do	.....	.....	Stock	4
1855	Mrs. Hale	....do	E-9	.....	....do	60	60	.....	29	....do	.....	.....	Domestic	Small.
1856	Ed. German	....do	E-9	.....	....do	61	61	400?	29	....do	.....	.....	....do	.....
1857	....do	....do	E-9	.....	Bored, 5-inch	61	61	400?	....	....do	.....	.....	Irrigation	Small.
1858	....do	....do	E-9	.....	Bored, 2-inch	61	61	400	27	....do	.....	.....	....do	4
1859	Frank Mott	....do	F-9	1899	....do	61	61	350	28	....do	.....	.....	Domestic; irrigation.	.....
1860	....do	....do	F-9	1899	....do	61	61	350	27	....do	.....	.....	Irrigation	.....
1861	A. A. Lewis	....do	F-9	1897	....do	61	61	528	27	....do	.....	.....	Domestic	.....
1862	....do	....do	F-9	1897	....do	61	61	525	28	....do	.....	.....	Stock	Small.
1863	....do	....do	F-9	1897	....do	61	61	525	25	....do	.....	.....	Stock; irrigation	.....
1864	....do	....do	F-9	1899	....do	61	61	525	28	....do	.....	.....	....do	3
1865	J. D. Fredericks	....do	F-9	1897	....do	61	61	150	26	Wind	$75.00	.....	Domestic	.....
1866	....do	....do	F-9	1897	....do	61	61	150	25	Artesian	.....	.....	Stock	Small.
1867	E. F. Gaines	....do	F-9	1900	....do	61	61	250	25	....do	150.00	.....	Domestic; stock	.....
1868	....do	....do	F-9	1900	....do	61	61	250	24	....do	150.00	.....	Domestic	.....
1869	....do	....do	F-9	1900	....do	61	61	250	23	....do	150.00	.....	Irrigation	2
1870	J. A. Wooley	....do	F-9	1898	Bored, 2½-inch	61	61	240	25	Artesian, wind	60.00	.....	Domestic	.....
1871	....do	....do	F-9	1898	Bored, 2-inch	61	61	590	29	Artesian	.....	.....	Not used	†5
1872	W. F. Harding	....do	F-9	1901?	....do	60	60	250?	25	....do	.....	.....	Domestic; irrigation.	Small.
1873	Mrs. Sweeney	....do	F-9	1899?	....do	57	57	64	25	....do	25.00	.....	Stock	Small.

1874	L. S. Kirkpatrick	do	F-9	1900	do	57	57	64	24	Wind	25.00		Domestic; stock		
1875	J. R. & W. A. Clark	do	F-9	1902	Bored, 10-inch	62	62	645	24	Artesian	1,306.50		Irrigation	65	
1876	do	do	F-9	1897	Bored, 7-inch	62	62	645	24	do			Stock; irrigation	19	
1877	do	do	G-10	1901	Bored, 12-inch	61	61	802	24	do	1,500.00		Irrigation	27	
1878	do	do	G-10	1895	Bored, 2-inch	61	61	640	24	do			Domestic		
1879	do	do	G-8	1890?	Bored, 7-inch	61	61	250?	24	do			Stock	Small.	
1880	do	do	G-10	1890	do	61	61	250?		do			do	Small.	
1881	do	do	G-10	1899	Bored, 10-inch	57	57	645	24	do			Irrigation	6	
1882	do	do	G-10	1896	Bored, 2-inch	56	56	250	25	do			Domestic	Small.	
1883	do	do	G-10	1894	do	52	52	250	24	do	62.50		do	Small.	
1884	R. T. Neeley	do	G-9		do	62	62		25	do			do		
1885	R. L. Andrews	do	G-9	1899	do	62	62	147	24	Wind, artesian	50.00		do	2	
1886	John Gessford	do	G-9	1898	Bored, 4-inch	63	63	450?	25	Artesian			do	Small.	
1887	do	do	G-9	1901	Bored, 12-inch	64	64	450		Gas	1,000.00	$500.00	Irrigation	75	
1888	Jothan Bixby	do	G-9	1894	Bored, 4-inch	61	61	150	25	Artesian, hand			Domestic	Small.	
1889	do	do	G-9	1898	Bored, 10-inch	60	60	640	25	Artesian	1,500.00		Irrigation	39	
1890	do	do	G-9	1896	Bored, 7-inch	61	61	680	25	do	1,500.00		do	42	
1891	do	do	H-8	1900	Bored, 10-inch	70	70	680	25	do	1,500.00		do	18	
1892	do	do	G-9	1897	Bored, 2-inch	61	61	600	24	do			Domestic		
1893	do	do	H-8	1895	do	66	66	150?	26	do			Stock	Small.	
1894	do	do	H-8		Bored, 7-inch	62	62	150	34	do			Domestic	Small.	
1895	J. W. Furnivall	do	H-8	1900	Bored, 2-inch	67	67	165	27	do	65.00		do	Small.	
1896	T. Gregory	do	G-9	1873?	Bored, 7-inch	65	65	140	25	do			do		
1897	do	do	G-9	1900	Bored, 2-inch	65	65	150	25	do	60.00		Domestic; stock		
1898	W. A. Reeves	do	G-9	1899	do	66	66	135	24	do	40.50		Domestic		
1899	Mrs. Mary Dougherty	do	G-9	1899	do	67	67	160?	24	do			do		
1900	A. Meissen	do	G-8	1903	do	71	71	146	23	do	65.70		Stock	4	
1901	D. Henderson	do	G-8	1899	do	71	71	140	25	do	50.00		do	Small.	
1902	W. Walton	do	G-8	1893	Bored, 7-inch	70	70	160	25	do			Not used		
1903	do	do	G-8	1896	Bored, 2-inch	71	71	140		do			do		
1904	do	do	G-8	1896	do	71	71	150		do			do		
1905	D. Henderson	do	G-8	1891	Bored, 7-inch	70	70	170	25	Artesian, wind	255.00		Domestic; stock	Small.	
1906	do	do	G-8	1896	Bored, 2-inch	69	69	209	25	Artesian	80.00		Stock	Small.	
1907	Mrs. Peterson	do	G-8		do	73	73	140	26	do			do	2	
1908	Mr. Sharpe	do	G-8		do	75	75		24	do			do	Small.	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1909	Mr. Wright	Los Cerritos	G-8	1900	Bored, 2-inch	72	72	150	24	Artesian			Stock	Small.
1910	T. Gregory	do	G-9	1894	do	69	69	140	24	do	$50.00		Domestic; stock.	Small.
1911	do	do	G-9	1897	do	69	69	625		do	200.00		Not used	
1912	do	do	G-9	1897	do	69	69	625		do	200.00		do	
1913	W. D. Thorn	do	F-9	1896	do	69	69	150		do			Stock	Small.
1914	John Newton	do	G-8	1899	do	71	71	130		do			Domestic; irrigation.	3
1915	A. Meissen	do	F-8	1899	do	71	71	118		do	58.00		Domestic; stock.	3
1916	do	do	F-8	1900	do	71	71	165	25	do	66.00		Domestic	
1917	do	do	F-8	1902	Bored, 7-inch	72	72	128		do	128.00		Irrigation	
1918	Mr. Sudor	do	G-8	1900	Bored, 2-inch	72	72	135	25	do	54.00		Stock	2
1919	Doctor McBurney	do	G-8	1899	do	72	72	140	25	do			do	2
1920	do	do	G-8	1899	do	73	73		25	do			do	Small.
1921	T. Gregory	do	F-8	1898	do			140		do	56.00		do	Small.
1922	Mrs. L. H. Germain	do	F-8	1899	do	73	73	144	25	do			do	2
1923	do	do	F-8	1898	do	73	73	149	25	do	59.60		do	
1924	do	do	F-8	1898	do	73	73	152		Gas, artesian	60.80		Domestic	2
1925	Mrs. Stella Meissein	do	G-8		do	74	74		25	Artesian			Not used	
1926	E. A. Keller	do	F-8	1895	do	75	75	177	24	Artesian, hand	80.00		Domestic	
1927	Miss O'Connor	do	F-8	1898	do	76	76	250	23	do	80.00		Irrigation	Small.
1928	Mr. Peterson?	do	G-8		do	76	76		24	do			Stock	Small.
1929	P. P. Donlay	do	G-8	1887?	do	78	78	160		Hand			Domestic	
1930	do	do	G-8		Bored, 7-inch	79	79	160		do			do	
1931	T. F. Downs	do	F-8	1902	Bored 2-inch	78	78	150?	22	Wind	136.75	$228.00	do	

1932	.....do.....	.....do.....	F-8.....	1901	.....do.....	78	78	.....	24	Artesian.....	84.45	.....	Stock.....	Small.
1935	J. S. Davee.....	Los Coyotes.....	J-8.....	1903	Dug, 3½ by 3½ foot.	73	66	9	63	Hand.....	.....	.....	.....do.....	.....
1936	C. Nottingham.....	.....do.....	J-8.....	1903	Hydraulic, 2-inch.	72	72	100	37	Artesian.....	50.00	.....	.....do.....	3
1937	M. Sproul.....	.....do.....	J-7.....	1898	Bored, 2-inch.....	92	.....	98	48	Wind.....	.....	.....	Domestic; stock.	1
1938	M. T. Wright.....	.....do.....	J-8.....	.....	.....do.....	90	90	650?	23	Artesian.....	.....	.....	Domestic.....	Small.
1939	.....do.....	.....do.....	J-8.....	1895?	Bored, 14-inch....	89	89	903	....	.....do.....	.....	.....	Irrigation.....	16
1940	D. D. Johnston.....	.....do.....	K-7.....	1900	Bored, 10-inch....	88	88	760	27	.....do.....	2,500.00	.....	.....do.....	3
1941	.....do.....	.....do.....	K-8.....	1877	Bored, 7-inch.....	87	87	620	23	Wind.....	1,200.00	50.00	Domestic.....	.....
1942	S. J. Wicks.....	.....do.....	K-7, 8...	1898	Bored, 2-inch.....	86	86	320	24	Artesian.....	80.00	.....	.....do.....	1
1943	Mrs. Holmes.....	.....do.....	K-8.....	1898	Hydraulic, 2-inch.	81	81	511	24	.....do.....	125.00	.....	.....do.....	Small.
1944	John Dolland.....	.....do.....	K-8.....	1893	Bored, 7-inch.....	82	82	550	25	.....do.....	1,000.00	.....	Stock.....	106
1945	.....do.....	.....do.....	K-8.....	1893	Bored, 2-inch.....	82	82	500	24	.....do.....	300.00	.....	.....	1
1946	.....do.....	.....do.....	J-8.....	1898	.....do.....	80	80	150	....	.....do.....	125.00	.....	Stock.....	.....
1947	T. S. Dunn.....	.....do.....	K-7.....	1899	.....do.....	91	91	450	26	.....do.....	100.00	.....	Domestic.....	Small.
1948	R. Phillips.....	.....do.....	K-7.....	1883	Bored, 4-inch.....	94	82	100	45	Gas.....	.....	287.00	.....do.....	.....
1949	M. A. Pendleton.....	.....do.....	K-7.....	1883	.....do.....	95	70	100	75	Wind.....	.....	.....	.....do.....	.....
1950	.....do.....	.....do.....	K-7.....	1902	Bored, 7-inch.....	95	.....	100	30	Hand.....	.....	.....	Stock.....	.....
1951	M. Sproul.....	.....do.....	K-7.....	1888	Hydraulic, 2-inch.	87	87	120	25	Artesian.....	60.00	.....	.....do.....	Small.
1952	M. Coulon.....	.....do.....	K-8.....	1895	Bored, 2-inch.....	78	78	370	23	.....do.....	170.00	.....	Domestic.....	†1
1953	Mr. Hunt.....	.....do.....	K-8.....	1883	Bored, 7-inch.....	77	.....	120	32	Wind.....	500.00	50.00	.....do.....	.....
1954	.....do.....	.....do.....	K-8.....	1883	.....do.....	78	78	120	....	Artesian.....	500.00	.....	Stock.....	Small.
1955	Edwin Cawston.....	.....do.....	K-8.....	1896?	Bored, 2-inch.....	76	76	498	23	.....do.....	.....	.....	Domestic.....	.....
1956	.....do.....	.....do.....	K-8.....	1896	.....do.....	76	76	330	22	.....do.....	.....	.....	Stock.....	.....
1957	E. A. Venable.....	.....do.....	K-7.....	1896	.....do.....	70	70	550	23	.....do.....	.....	.....	Domestic; stock.	2
1958	.....do.....	.....do.....	L-8.....	1896	Bored, 7-inch.....	72	72	100	32	Hand.....	.....	.....	Domestic.....	.....
1959	B. Branscon.....	.....do.....	L-8.....	1897	Hydraulic, 2-inch.	73	73	500	25	Artesian.....	185.00	.....	Irrigation.....	5
1960	J. M. Frazer.....	.....do.....	L-8.....	1900	Bored, 2-inch.....	77	77	565	....	.....do.....	250.00	.....	.....do.....	1½
1961	.....do.....	.....do.....	L-8.....	1902	.....do.....	76	76	555	24	.....do.....	180.00	.....	Domestic; irrigation.	†2
1962	C. H. Mettler.....	.....do.....	L-8.....	1887	Bored, 7-inch.....	77	72	80	37	Wind.....	.....	.....	Domestic.....	.....
1963	A. T. Wilkinson.....	.....do.....	L-8.....	.....	Bored, 2-inch.....	75	.....	90	38	.....do.....	.....	.....	.....do.....	.....
1964	Will Clanton.....	.....do.....	L-8.....	.....	Driven, 4-inch....	77	.....	60	37	Hand.....	.....	.....	.....do.....	.....
1965	W. A. Thompson.....	.....do.....	L-8.....	1883	Bored, 7-inch.....	78	78	393	24	Artesian.....	.....	.....	Domestic; stock.	Small.
1966	.....do.....	.....do.....	K-8.....	1898	Bored, 2-inch.....	80	80	500	29	.....do.....	200.00	.....	Stock.....	Small.
1967	Wm. Newton.....	.....do.....	L-8.....	1890	.....do.....	83	83	717	28	.....do.....	186.00	.....	Irrigation.....	7

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
1968	Wm. Newton	Los Coyotes	L-8	1891	Bored, 2-inch	83	83	724	24	Artesian	$253.00		Domestic; irrigation.	1½
1969	J. M. Frazer	do	L 8		do	81	81	830	31	do			Stock	1
1970	do	do	L 8		Bored, 3-inch	81	81	550	40	do			do	Small.
1971	E. Thowson	do	L 7		Bored, 4-inch	85	78	57	32	Hand			do	
1972	John Baker	do	L 7	1898	Bored, 2-inch	87		115?	39	do			Domestic	
1973	I. Hnadle	do	K, L 7	1891	Bored, 7-inch	92	92	114		Wind	120.00		Domestic; stock	
1974	I. W. Inman	do	K 7	1891	do	91	86	104	38	do	117.00	$30.00	Stock; irrigation	
1975	do	do	K 7	1897	Bored, 2-inch	95	95	675		Artesian	200.00		do	
1976	John Baker	do	K 7	1897	do	88	86	70	45	Wind	25.00	30.00	Stock	
1977	A. W. Surbeck	do	K 7	1890	Bored, 7-inch	88	82	84	57	do	85.00	350.00	Domestic	
1978	do	do	K 7	1897	Bored, 2-inch	85	83	80	49	Hand	40.00	10.00	Stock	
1979	D. Mabry	do	K 7	1895?	do	89		90	55	do	45.00		Domestic	
1980	L. M. McConnell	do	K 8	1895	do	79		92	47	do	45.00		do	
1981	Geo. W. Wardell	do	K 8	1902	do	79	79	476	25	Artesian	190.00		Irrigati	1
1982	do	do	K-8	1900	do	79	75	76	37	Hand	37.50		Domestic	
1983	S. Wardell	do	L 8		do	79	79	650	26	Artesian			Stock	1½
1984	W. H. Miller	do	K-8	1903	do	80		89		Gas	230.00		Irrigation	
1985	H. E. Belfield	do	L 8	1899	do	73	73	505	25	Artesian	200.00		Domestic	2
1986	do	do	L-8	1896	do	72	72	300	25	do	175.00		do	1½
1987	do	do	L-8		Bored, 4-inch	71		75	37	Wind			do	
1988	W. Hungerford	do	L 8, 9	1873?	Bored, 7-inch	70	70	400	32	Artesian			Domestic; stock	1
1989	J. R. Mitchell	do	L 8	1878	do	69	68	180	31	Hand			Stock	
1990	do	do	L-8, 9	1900	Bored, 3-inch	67	67	600		Artesian	275.00		Irrigation	3

1991	A. T. Wilkinson	do	L-8	1901	Bored, 2-inch	75	75	226		do	125.00		do	†1
1992	J. N. Smith	do	L-8	1881	Bored, 7-inch	74	73	283	29	Hand	500.00		Domestic	
1993	do	do	L-8	1886?	do	73	69	163		do	150.00		Not used	
1994	W. P. Eshon	do	M-8	1901	Bored, 2-inch	72	72	73		Artesian	35.10		Domestic; stock	Small.
1995	Wm. Newton	do	M-8		do	65	65	570	47	do			Stock; irrigation	†1
1996	J. F. Overton	do	N-10	1901	Bored, 3-inch	64	64	280	51	do			Domestic; irrigation.	4
1997	do	do	N-10	1885?	do	65	65	230	35	Artesian, wind			do	
1998	J. F. Hamm	do	N-10	1897?	do	66	65	90	39	Artesian	40.00		Domestic	
1999	C. F. Robinson	do	N-10	1896	do	70	70	167	38	do			Domestic; stock	Small.
2000	A. C. Mann	do	N-10	1901	Bored, 2-inch	65	65	75	37	do	40.00		Domestic	Small.
2001	John Kellenberger	do	N-10	1898	Bored, 3-inch	64	64	220	38	do	90.00		Stock; domestic	Small.
2002	U. S. Scales	do	N-10	1893?	Bored, 2-inch	62	62	450	38	do			Domestic; irrigation.	Small.
2003	W. A. Tracy	do	N-10	1898	Hydraulic, 4-inch	70	70	265		do	210.00		do	
2004	M. Raymond	do	N 10	1896?	Bored, 4-inch	69	69	190	35	Artesian, hand			do	Small.
2005	H. G. Bixby	do	N-10	1898?	Bored, 3-inch	73	73	190	38	Wind			Domestic	Small.
2006	S. R. Brewer	do	N-10	1898	Bored, 2-inch	74	74	190	36	do	70.00	140.00	do	
2007	J. H. Whitaker	do	N-10	1897	do	75	75	200	35	Artesian, wind	75.00	142.50	do	Small.
2008	N. V. Brown	do	N-10	1901	do	74	74	199	33	Wind	80.00	100.00	do	
2009	D. W. Hasson	do	N-10	1898	Bored, 3-inch	73	73	268	37	Artesian	150.00		Domestic; irrigation.	
2010	John Cowan	do	N-10	1894?	Bored, 6-inch	71	71	250	36	do	250.00		Domestic	
2011	do	do	N 10	1897	do	70	70	250	33	do	250.00		Stock	
2012	J. Porte	do	N-9		Bored, 2-inch	70	65	200	39	Hand			Domestic	
2013	C. J. Deodeon	do	N-9	1894	Bored, 7-inch	66	66	420	59	Artesian	300.00		Irrigation	
2014	do	do	N-9	1897	Bored, 10-inch	67	67	425		do	400.00		Stock	
2015	do	do	N-9	1893?	Dug, 3 by 3 foot	68	65	5	35	Hand			do	
2016	C. L. McComber	do	N-8	1898	Bored, 7-inch	105	101	450	32	Wind		160.00	Domestic	
2018	Geo. B. Reebe	do	N-8	1898	Bored, 10-inch	136	96	450	43		1,439.00	1,500.00	Irrigation	10
2019	do	do	N-8	1896	Bored, 10-inch, 600 feet; 8-inch, 50 feet; 6-inch, 250 feet.	125	75	900	31	Gas	4,140.50		do	15
2020	do	do	N-8	1902	Bored, 10-inch	213	213	1,360	55	Artesian	8,280.00		do	2
2021	E. D. Wood	do	N-8	1903	Dug, 4 by 4 foot	78	59	22	72	Wind			Domestic	
2022	do	do	M-8	1902	Dug, 3½ by 3½ foot	73	69	8		Hand			Stock	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
2023	S. Forbes	Los Coyotes	M 8	1898?	Bored, 2-inch	72	72	600	31	Artesian			Domestic; irrigation.	1
2024	J. W. Brown	do	M 8	1879	do	73	71	90	45	Hand	$21.00		Domestic	
2025	B. W. Hutchinson	do	M 8	1897	do	73	63	92	36	do	90.00		do	
2026	do	do	M 8	1879	Hydraulic, 2-inch	74	74	526		Artesian	225.00		Irrigation; stock	6
2027	J. W. Brown	do	M 8	1880	Bored, 2-inch	72	67	61	61	Hand	24.00		Stock	
2028	I. S. Copeland	do	M 7 8		do	95	95	600?	44	Artesian			Domestic	
2029	do	do	M 7	1891	Bored, 10-inch	93	93	750?	43	Gas			Stock	10
2030	Mr. McNally	do	M 8	1894	Bored, 8-inch	97	97	441	35	Gas, artesian	555.00	$1,300.00	Irrigation; domestic.	40
2031	do	do	M 7	1891	Bored, 7-inch	133		480			212.50			
2032	do	do	M 7		Bored, 8-inch			500		Gas			Irrigation	
2033	do	do	N 6	1891?	Bored, 10-inch			634					Not used	
2034	do	do	M 7	1895	do	152	152	609		Gas, artesian	1,200.00		Irrigation	Small.
2035	do	do	M 7	1900	do	135	135	680	98	Artesian			do	†25
2036	C. Underwood	do	M 6		Bored, 7-inch	125	125	198		do			Domestic; stock	
2037	do	do	M 6,7	1897	do	125	125	450	56	do	880.00		Domestic	
2038	Geo. B. Reebe	do	M 7	1895?	Bored, 2-inch	100	100	500?	45	Hand				
2039	do	do	L-6,7	1900	Bored, 3-inch	80	80	815	85	Artesian			Irrigation	
2040	do	do	L-6,7	1900	do	80	80	818	78	do			do	
2041	H. B. Hawk	do	M 7		Bored, 2-inch	125	125	400?		Wind			do	
2042	do	do	M 7	1894	Bored, 7-inch	125	108	415		do	800.00		do	
2043	do	do	M 7		Bored, 10-inch	105	104	400?	36	Gas		1,000.00	Irrigation; domestic.	

2044	John Vaughn	do	M-7		Bored, 2-inch	85	85	580		Artesian			Stock	Small.
2045	do	do	L-7	1896	do	97	97	615	37	Wind, artesian	280.00	175.00	Domestic	
2046	do	do	L-7	1896	do	98	98	620		Wind	282.80	150.00	Stock	
2047	do	do	L-6	1896	do	100	100	610	26	Artesian	278.00		do	†1
2048	do	do	L-7	1897	Bored, 12-inch	90	90	144		Gas	395.00	400.00		
2049	Benj. Branscom	do	L-7	1900	Bored, 3-inch	95	95	750	47	Artesian	425.00		Not used	
2050	do	do	L-7	1900	Bored, 2-inch	95	95	810	49	do	325.00		do	†1
2051	Lee Seabridge	do	L-7	1901	do	87		157	34	Wind			Stock	
2052	J. B. Thornton	do	L-7	1899	Bored, 3-inch	85	85	678		Artesian	250.00		Stock; irrigation	
2053	do	do	L-7	1895?	Bored, 2-inch	86	86	490	34	do	135.00		Domestic; stock	Small.
2054	H. H. Venable	do	K-7	1897	do	97	97	513	25	do	190.00		Domestic	Small.
2055	W. W. Clanton	do	K-7	1880?	Bored, 4-inch	99	88	80	55	Wind		150.00	do	
2056	J. M. Clanton	do	K-7	1888?	do	98	86	404	43	do		150.00	do	
2057	J. W. Porter	do	K-7	1902	Bored, 10-inch	97	87	223	22	Steam	376.00	940.00	Irrigation	96
2058	do	do	K-7	1895	Bored, 2-inch	97	95	425	21	Wind	215.00	150.00	Domestic	
2059	John Venable	do	K-7	1891	Dug, 4 by 4 foot	100	91	12	77	do				
2060	J. N. Clanton	do	K-7	1898	Bored, 3-inch	107	95	62	54	do		180.00	Domestic	
2061	R. B. Venable	do	K-6	1896?	Bored, 2-inch	115	107	130	49	do	50.00	75.00	do	
2062	M. Meyer	Santa Gertrudis	K-6	1901	Dug, 3½ by 3 foot	125	105	22	91	Hand			Stock	
2063	Mrs. S. Bland	Los Coyotes	L-6		Bored, 7-inch	113	105	356	34	Wind			Domestic	
2064	do	do	L-6	1902	Bored, 12-inch 5-inch.	113	113	735	78	Artesian			Irrigation	8
2065	W. H. Harp	do	L-6	1897	Bored, 8-inch	125	109	568	57	Wind	950.00	150.00	Domestic; irrigation.	
2066	do	do	L-6	1899	Hydraulic, 3-inch	125	125	703		Artesian	350.00		Stock; irrigation	†3
2067	M. Meyer	Santa Gertrudis	L-5	1902	Bored, 7-inch	175	159	125	75	Wind	120.00	125.00	Domestic	
2068	John S. Baker	do	K-5	1887	do	162	128	110	51	do	125.00	180.00	do	
2069	do	do	K-5	1901	Bored, 10-inch	175	152	398			2,023.00		Not used	
2070	do	do	K-5	1901	Bored, 8-inch	175	152	435						
2071	do	do	K-5	1897	Bored, 7-inch	155	119	52	56	Wind		125.00	Domestic	
2072	Los Angeles National Bank.	do	K, L-5	1894?	Bored, 4-inch	168	134	60	47	Gas			Domestic; irrigation.	
2073	C. H. Benton	do	L-5	1892	do	170	135	70	51	Wind	56.00	300.00	Domestic	
2074	do	do	L-5	1899	Hydraulic, 2-inch	170		804						
2075	Mrs. W. A. Gunn	do	L-5	1878?	Bored, 5½-inch	165	138	300	57	Gas		480.00	Domestic	
2076	do	do	L-5	1891	Bored, 4-inch	163	133	120		Hand			Stock	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
2077	E. Wickman	Santa Gertrudis	K-5	1898	Dug, 3 by 4 foot			35		Wind			Domestic	
2078	Railroad station	do	K-5	1897	Bored, 4-inch	158	128	80	27	Hand	$70.00			
2079	W. B. Ellis	do	K-5	1900	Driven, 3¼-inch	164	130	37	47	do	45.00		Domestic; stock	
2080	Mr. Hollenbeck	do	K-4	1900	Dug, 4-foot diameter.	162	130	35	63	Wind	50.00	$125.00	Domestic	
2081	C. H. Girdlestone, agent	do	K-5		Bored, 7-inch	157	127	190	29	do			do	
2082	Frank Groves	do	K-5		Dug, 4 by 4 foot	159	134	28		Hand				
2083	C. H. Girdlestone, agent	do	K-5	1874	Bored, 7-inch	179		300	75	do			Domestic	
2084	do	do	K-5		do	159	142	300	81	Wind			do	
2085	J. W. Weaver	do	J-K-4	1902	Dug, 3½-foot diameter.	159	132	30	53	Hand	40.00		do	
2086	C. C. Mason	do	K-5	1888	Bored, 7-inch	159	134	52	80	Wind	105.00	110.00	do	
2087	do	do	K-4	1888	do	159	134	85		do	170.00	115.00	Domestic; stock	
2088	Mrs. L. Hem	do	J-5	1903	Dug, 2-foot diameter.	155	128	30	66	Hand	52.50		Domestic	
2089	J. M. Ellis	do	K-5	1893	Dug, 4-foot diameter.	156	128	31	94	do	45.00		do	
2090	O. Blanchard	do	K-5		Dug, 2-foot diameter.	168	136	36		Wind	50.00		do	
2091	C. W. Duncan	do	K-5	1891	Bored, 2-inch	168	138	127	41	do	140.00		do	
2092	J. S. Buckbee	do	K-5	1899	Dug, 3½ foot diameter.	166	132	37	38	do	40.00	110.00	do	
2093	John S. Baker	do	K-5		Bored, 7-inch	150	118	108	39	Hand	125.00		do	
2094	C. Palm	do	K-5	1896	Bored, 2-inch	161	140	275	62	do			do	
2095	P. Bedler	do	J-5	1895?	do	140		105	31	do	50.00		do	

2096	J. C. Clark	do	J-5		do	112	130	187	51	do			Stock			
2097	do	do	J-5		Bored, 4-inch	144		60?	52	Wind	55.00	150.00	Domestic			
2098	John Paddison	do	J 7		do	152		110?	34	do			do			
2099	J. W. Sharp	do	J-5	1877?	Bored, 7-inch	150		380					Not used			
2100	do	do	J 5	1877?	do	145		380	56	Wind			Domestic			
2101	do	do	J 5	1902	Bored, 12-inch	130		94	39	Gas?						
2102	do	do	J 5	1903	do	130		94?		do						
2103	J. S. Brown	do	J-5	1893?	Bored, 2-inch	135		385	60	Wind			Domestic			
2104	do	do	J 5		Bored, 7-inch	133		385?		Hand			Not used			
2105	J. H. Haddock	do	J 5	1902	Bored, 4-inch	140	129	117	38	do	102.00		Domestic			
2106	A. Loveall	do	J 5	1901	Bored, 5-inch	130	118	66	44	Wind	55.00		do			
2107	Fred Hunsaker	do	J 5	1889	Bored, 3-inch	130	105	80	45	do			do			
2108	C. B. Woodhead	do	J-5	1880?	Bored, 7-inch	127							Not used			
2109	do	do	J 5	1898?	Bored, 8-inch	125		702	62	Artesian			Stock		20	
2110	do	do	J-5		Bored, 3-inch?	133			37	Wind			Domestic			
2111	A. C. Ramirez	do	J-5		Bored, 4-inch	144		68	60	do			do			
2112	John W. Rannalls	do	K 6	1903	Bored, 5-inch	125	120	381			450.00		Not installed			
2113	do	do	J-6	1893	do	116	76	50	65	Hand	50.00		Domestic			
2114	Mr. Obair	do	J-6	1903	Bored, 12-inch	117	112	730	24	Gas, wind		1,000.00	Domestic; irrigation.		80	
2115	John Paddison	do	J-6	1902	do	117	110	250		Gas	500.00	800.00	Irrigation		†50	
2116	do	do	J-6	1884	Bored, 4-inch	115	113	267	35	Wind		150.00	Domestic			
2117	Norwalk Co. Creamery.	Los Coyotes	J-7		Bored, 2-inch	112		450	22	Hand			do			
2118	Mrs. A. M. Sproule	do	J-7	1900	do	102	87	150	34	do			Stock			
2119	J. S. Bland	do	J-7	1902	do	100		100	50	Wind	52.00	88.00	Domestic			
2120	Mrs. A. M. Sproule	do	J-7	1899	do	101		660			400.00		do			
2121	F. Hawkins	do	J-7	1901	Bored, 3-inch	98		110	39	Wind	60.00		do			
2122	J. S. Elliot	do	J-7	1897	Bored, 2-inch	99	95	490	26	do	375.00		do			
2123	E. Stiffler	do	J-7		Bored 4-inch	99	89	100?	61	do			do			
2124	Mrs. F. A. Haddock	do	J-7	1901	do	100	88	90	56	do	55.00	125.00	do			
2125	Norwalk Building Association.	do	J-7	1893	Bored, 7-inch	100	89	97	51	do	125.00	225.00	do			
2126	R. A. Byron	do	J-7	1900	Bored, 8-inch	100	89	104	53	Gas	110.00	375.00	do			
2127	J. Swagart	do	J-7	1886?	do	100		104	64	Wind			do			
2128	L. Langley	Santa Gertrudis	J-7	1801	Bored, 2-inch	103		40	53	Hand			do			

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
2129	J. Watson	Santa Gertrudis	J-6		Bored, 2-inch	108	.....	165	40	Hand			Domestic	
2130	W. W. McElhiney	do	J-6	1882?	Bored, 4-inch	109	101	312	25	Wind			do	
2131	W. W. Orr	do	J-6	1883	Bored, 7-inch	118	109	50	46	do	$52.00	$100.00	Stock	
2132	do	do	J-6	1898	do	117	107	50	62	do	50.00	.....	Domestic	
2133	C. E. O'Conner	do	J-6	1898	Bored, 2-inch	122	.....	72	91	do	23.00	270.00	do	
2134	do	do	J-5	1900	Bored, 12-inch	122	114	109	.....	.....	170.00	.....	Not used	
2135	J. D. Crawford	do	J-5	1885?	Bored, 4-inch	128	116	62	102	Wind			Domestic	
2136	S. J. Lovell	do	J-5	1899	Dug, 4 by 4 foot	124	117	10	96	Hand			do	
2137	O. Newlan	do	I-5		Bored, 4-inch	127	.....	35	80	do			do	
2138	R. H. Haddock	do	I-5	1903	Bored, 12-inch	129	118	96	59	Gas	180.00	600.00	Irrigation	
2139	D. E. Haddock	do	I-5	1884	Bored, 2-inch	131	118	57	61	Hand			Domestic	
2140	J. F. Moore	do	I-5	1902	Bored, 5-inch	130	118	44	52	do	38.00	.....	do	
2141	L. W. Houghton	do	I-4	1896	Bored, 2-inch	130	118	60	40	do			do	
2142	do	do	I-4	1899	Bored, 12-inch	129	.....	50	.....	Gas?	75.00	.....	Irrigation	
2143	do	do	I-4	1899	Bored, 10-inch	129	129	775	23	Gas, artesian	2,000.00	1,625.00	do	
2144	W. W. Orr	do	J-4	1896	Bored, 8-inch	141	132	36	50	Wind	35.00	200.00	Stock	
2145	Mrs. Carey	do	J-4	.....	do	141	131	44	51	do			Domestic	
2146	L. W. Houghton	do	I, J-4	.....	Dug, 4 by 4 foot	133	121	16	32	Hand			do	
2147	J. C. Dashiell	do	I-5	1896?	Bored, 2-inch	122	112	51	55	Wind	50.00	200.00	Stock; domestic	
2148	Mr. Schendoney	do	I-5	1903	Bored, 3-inch	120	.....	55	78	do			Domestic	
2149	L. W. Houghton	do	I-5	1903	Bored, 5-inch	119	107	57	30	Hand	51.30	.....	do	
2150	do	do	I-5	1900	Driven, 4-inch	116	104	34	40	Wind		210.00	do	
2151	Mr. Glasselle	do	I-5	1882	Bored, 5-inch	114	104	63	57	do			do	

2152	L. W. Houghton	do	I-5	1900	Bored, 4-inch	116	104	54	57	do	40.00	150.00	do				
2153	B. M. Moore	do	I-5	1903	do	118	106	63	69	do	56.70		do				
2154	Mrs. F. A. Haddock	do	I-5	1880?	Bored, 8-inch	121	115	300?	28	do			do				
2155	J. N. Newlan	do	I-5	188–	Bored, 4-inch	120	110	45?	75	do		150.00	do				
2156	H. W Beest	do	J-5	188–	do	122	111	50	42	Hand			do				
2157	J. N. Newlan	do	I-5	1880	Bored, 2-inch	117		50		do			do				
2158	do	do	I-6	1900	Dug, 3 by 3 foot	117	97	13		do			Stock				
2159	Frank Irish	do	J-6	1892	Bored, 8-inch	107	99	64	54	Wind			Domestic				
2160	L. J. Bever	do	J-6	1902	Bored, 5-inch	105	97	50	73	do	42.50	150.00	do				
2161	R. W. Hill	do	I-6	1899	Bored, 3-inch	104	97	75	37	Hand			Stock				
2162	J. A. Worthen	do	I-6		Bored, 2-inch	105	98	80?	37	Wind			Domestic				
2163	W. W. Clemons	do	I-6	1890	Bored, 4-inch	102		62	47	do			do				
2164	E. J. Hill	do	I 6	1888	do	102	98	62	50	Hand	40.00		do				
2165	do	do	I-6	1892	Bored, 12-inch	102	98	87		Gas	175.00	1,000.00	Irrigation	80			
2166	Chas. Emery	do	I-6	1888	Driven, 2-inch	101		28?		Hand			Domestic				
2167	Morton Bros	do	I-6		do	102		30	45	do			do				
2168	J. K. Brenizer	do	I-5	1882	Bored, 4-inch	110	100	63	52	do	63.00		do				
2169	do	do	I-5	1902	Dug, 4 by 4 foot	110	100	14	200+	do			Stock				
2170	Chas. Collins	do	I-6	1903	Bored, 12-inch	108	98	237	28	Gas	474.00	2,120.00	Irrigation	†150			
2171	do	do	I-6	1903	do	108	98	241		do	482.00		do				
2172	do	do	I-6	1879?	Bored, 7-inch	108	95	125	40	Wind			Domestic				
2173	A. Pilkington	do	I-5, 6	1900	Bored, 4-inch	108	98	70	50	Hand			do				
2174	H. D. Kinney	do	I-5	1889?	do	108		62	54	do			do				
2175	N. T. Cowan	do	I-6	1900	do	108		64	47	do	32.00		do				
2176	E. C. White	do	I-6	1895?	Bored, 2-inch	107		42?	45	do			do				
2177	N. H. Hughes	do	I-6	1895	Bored, 4-inch	105	95	80	41	do	65.00		do				
2178	M. Long	do	I-6		Driven, 2-inch			20	56	do			do				
2179	do	do	I-6		Dug, 3 by 4 foot			12	140	do			Stock				
2180	Geo. A. Smith	do	I-6	1902	Bored, 2-inch	105		66	67	do			do				
2181	J. P. Green	do	I-6	1883	Dug, 2 by 3 foot	102	96	10	111	Hand			Domestic				
2182	do	do	I-6	1900	do	101	95	10	69	do			Stock				
2183	M. A. Murphy	do	I-6	1901	Bored, 2-inch	98		60?	47	do			Domestic				
2184	P. Benson	do	H-6		Bored 4-inch	97	93	79	48	do			do				
2185	G. M. Clark	do	I-6	1902	Bored, 12-inch	99	93	108		Gas	200.00	1,000.00	Irrigation	130			
2186	do	do	I-6	1880	Bored, 4-inch	98	93	62	61	Wind	40.00		Domestic				

Wells in the Downey quadrangle—Continued.

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						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
2187	Chas. Rodger	Santa Gertrudis	I-6	1884	Bored, 4-inch	96	96	299	28	Artesian	$400.00		Stock; domestic.	Small.
2188	Theo. Foster	do	I-7	1883	Bored, 7-inch	96	96	275	26	Artesian, hand	700.00		Domestic	
2189	Mr. Isabel	do	I-7	1903	Bored, 5-inch	92	87	98	56	Hand			Stock	
2190	J. V. Dilley	Los Coyotes	I-7	1885	Bored, 7-inch	87	90	311	24	Artesian	400.00		Domestic; stock.	Small.
2191	do	do	J-7	1883?	do	93	90	160			175.00		Stock	
2192	do	do	J-7	1875	do	96	96	280	27	Wind	800.00	$113.00	Domestic	
2193	do	do	J-7	1902	Bored, 2-inch	94	94	260	26	Artesian	200.00		Stock	Small.
2194	Mrs. E. Baker	Santa Gertrudis	I-6	1895	do	100		90	61	Wind			Domestic	
2195	S. Baker	do	J-6	1888	Bored, 8-inch	100	100	350	28		1,050.00		do	Small.
2196	Atwood Sproul	Los Coyotes	J-6	1875	Bored, 7-inch	99	99	457	26	Artesian	2,200.00		do	†3
2197	Union Oil Co	do	J-7	1902	Bored, 4-inch	98	87	87	35				Boilers?	
2198	A. Sproul	do	J-7	1870?	Bored, 7-inch	97	86	250	37	Wind			Stock	
2199	Railroad station	do	J-7	1903	Bored, 9½-inch	98	86	118	47	Not installed	215.00			
2200	A. R. Sebastian	do	J-7	1901	Bored, 2-inch	98	86	97	42	Wind	35.00	200.00	Domestic	
2201	E. P. Pruitt	do	J-7	1900	do	98	86	108	48	do	55.00	145.00	do	
2202	Belle-Vernon Farms Co.	do	J-7	1891	Bored; 4-inch	95		100	43	Hand	100.00		do	
2203	H. G. Borroughs	do	J-7	1901	Bored, 2-inch	95	84	110	42	Wind	55.00	125.00	do	
2204	M. D. Fraser	do	J-7	1902	Bored, 4-inch	95	83	104		do	82.00	250.00	do	
2205	W. Waymayer	do	J-7	1895?	Bored, 2-inch	94			22	do			do	
2206	W. H. Smith	do	J-7	1902	do	94		100	40	do	50.00	240.00	do	
2207	J. Seabridge	do	J-7	1901	do	93	81	100	40	do	55.00		do	
2208	J. J. Blair	do	J-7	1903	do	93	82	98	41	do	44.00	125.00	do	
2209	J. Haddock	do	J-7	1901	do	92	81	110	41	do	45.00		do	

2210	G. W. Sales	do	J-7	1898	do	92	92	640	26	Artesian			do	Small.
2211	Public school	do	J-7	1901	do	91		106	38	Wind	45.00		do	
2212	E. A. Branscon	Santa Gertrudis	I-7	1895	do	89	87	110	50	Hand	50.00		do	
2213	Geo. Branscon	do	I-7	1893	Bored, 4-inch	86		105	49	Wind			do	
2214	C. A. Phillips	do	H-7	1894?	Bored, 1½-inch	83	82	120		do	40.00		Stock	
2215	J. T. Hall	do	I-7	1891	Bored, 2-inch	89		55	40	Hand	35.00		Domestic	
2216	E. A. Branscon	do	I-7	1880	Bored, 4-inch	89	90	300+	25	Artesian			Stock	Small.
2217	John Meeks	do	H 7	1873	Bored, 7-inch	89	89	300	40	Hand			Domestic	
2218	do	do	H-6	1874	do	90	90	408	25	Artesian	1,600.00		Stock	1
2219	John Branscon	do	H-1,7	1895	Bored, 4-inch	91	89	55	38	Hand	35.00		Domestic	
2220	Mr. Jerome	do	H 6		do	91	88	56	45	do			do	
2221	A. M. Cox	do	H-6	1902	Bored, 5-inch	100		62	49	do	60.00		do	
2222	J. Moisa	do	H-6	1902	Bored	102		72?	57	do			do	
2223	T. W. Swain	do	H-6	1897	Bored, 2-inch	102		56	60	do	30.00		do	
2224	T. J. Sparks	do	H-6	1901	do	104	99	70	51	do	55.00		do	
2225	T. G. Golitzer	do	H-6	1879?	Bored, 4-inch	102	98	60	48	do			do	
2226	J. D. Evans	do	H-6	1885?	do	99	100	325	27	Artesian, hand			do	1
2227	Thos. Fagan	do	H-6	1902	Bored, 5-inch	96	93	62	47	Hand	52.00		do	
2228	G. A. White	do	H-6	1895	Bored, 2-inch	98		91	43	do	35.00		do	
2229	F. Bohring	do	H-6	1892	Bored, 4-inch	97	95	64	43	do	50.00		do	
2230	Mr. Krug	do	H-6		do	96		66?	41	do			do	
2231	E. E. Ball, jr.	do	H-6	1899	do	97		150?	38	Wind			do	
2232	do	do	H-6	1887?	do	97	95	98	33	do	80.00		Domestic; stock	
2233	G. W. Williamson	do	H-6	1885?	do	98		102?	37	do			Domestic	
2234	G. A. White	do	G-6	1890	do	98	94	64			45.00		Not used	
2235	John Zinn	do	G-6	1885?	do	97	94	94	31	Wind	67.00	106.00	Domestic	
2236	B. Thomas	do	H-6	1895	Bored, 2-inch	93		75		Hand	35.00		do	
2237	do	do	H-6	1884	Bored, 7-inch	92	92	240			250.00		Stock	
2238	F. M. Foster	do	G-7	1885	do	92	89	250	24	Hand	300.00		Domestic	
2239	O. C. Millett	do	G-6,7	1898	Bored, 10-inch	92	87	284		Gas	210.00	520.00	Irrigation	†85
2240	do	do	G-7	1903	Bored, 4-inch	90	86	86	31	Hand	68.00		Domestic	
2241	G. E. Foster	do	G-7	1903	Bored, 5-inch	89		84	33	do	62.00		do	
2242	do	do	H-7	1872	Bored, 7-inch	89		125	32	do			do	
2243	Mr. Wilcox	do	H-7		do	88	86	108	39	do			Stock	
2244	W. H. Andrews	do	H-7	1903	Bored, 2-inch	96	81	96	40	do	43.00		Domestic; stock	

Wells in the Downey quadrangle—Continued.

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						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
2245	N. Davee	Santa Gertrudis	H-7	1893	Dug, 3 by 4 foot	80	74	10	62	Hand			Domestic	
2246	F. Fleming	do	H-7	1902	Bored, 4-inch	75	72	124	34	do	$104.00		do	
2247	C. Blythe	Los Coyotes	H-8	1903	Bored, 2-inch	74	73	104	34	do	47.00		do	
2248	do	do	H-8	1888	do	73	73	103	32	Artesian			Stock	Small.
2249	Wm. Gregory	do	H-8	1894	do	74	74	150	29	Wind	90.00		Domestic	
2250	do	do	H-8	1898	Bored, 7-inch	73	73	100		Gas?	150.00	$85.00	Irrigation	
2251	Mr. Hess	Los Cerritos	G-8	1888?	Bored, 4-inch	77	74	126	30	Hand			Domestic; stock	
2252	Moyse & Weaver	do	G-7	1888	Bored, 5-inch	81	81	120	29	Artesian			Stock	
2253	James E. Hagar	do	G-8	1887?	Bored, 4-inch	81		80	21	Hand			Domestic	
2254	do	do	G-7	1888	Bored, 7-inch	82	77	210	26	Wind, gas	200.00	640.00	Irrigation	
2255	Mrs. Wyes	Los Coyotes	G-7	1887?	Bored, 4-inch	83		92	24	Wind			Domestic	
2256	Moyse & Weaver	Los Cerritos	G-7	1901	Bored, 6-inch	85		111	28	do			do	
2257	do	do	G-7	1902	Bored, 12-inch	86	80	567	26	Artesian, gas	1,556.00	1,356.00	Irrigation	+50
2258	P. O'Connor	do	G-7	1901	Bored, 2-inch	86	83	137	29	Wind	61.50		Domestic	
2259	do	do	G-7	1897	Bored, 10-inch	88	84	172		Gas	350.00	700.00	Irrigation	40
2260	J. R. Cooke	do	G-7	1876?	Bored, 7-inch	85	82	456	25	Hand	1,500.00		Domestic; stock	
2261	R. Casey	do	G-7	1901	Bored, 2-inch	88		90	27	do			Stock	
2262	H. T. Porter	Santa Gertrudis	G-7	1897?	do	90		116	30	do	52.00		Domestic	
2263	W. T. Strawbridge	do	G-7	1883?	Bored, 4-inch	90		120	29	do			do	
2264	do	do	G-7	1898	Bored, 10-inch	91	86	196		Gas			Irrigation	+50
2265	W. S. Grey	do	G-7	1896?	Bored, 2-inch	91		85	29	Hand	35.00		Domestic	
2266	do	do	G-7	1903	Bored, 4-inch	91		94	27	Gas	85.00	200.00	Irrigation	
2267	W. Spalding	do	G-7	1894?	Bored, 1½-inch	91		85	29	Hand	35.00		Domestic	

2268	Wm. Stooksberg	do	G-7	1891	Bored, 4-inch	93		66	30	do			do		
2269	A. E. Brittle	do	G-7	1890?	Bored, 2-inch	95		82	30	do			do		
2270	W. H. Porter	do	G-6	1897	Bored, 4-inch	96		85	30	do	75.00		do		
2271	E. E. Ball	do	G-6	1896	do	97		320	21	Wind	400.00	60.00	do		
2272	M. P. Snyder	do	G 6	1898	Bored, 2-inch	97		75	31	Hand			do		
2273	J. H Cooke	do	G-6	1884	Bored, 4-inch	100		56	30	Wind			Domestic; stock		
2274	V M. Hardy	do	G 6	1900	Dug, 3 by 3 foot	103	93	13	44	Hand			Domestic		
2275	T Bright	do	G 6	1898	Bored, 6-inch	102	97	98		do	110.00		Not used		
2276	James Bacon	do	G 6		Bored, 4-inch	105		90	30	do			Domestic		
2277	Cochran & Williams, agents	do	G-6		Dug, 4 by 4 foot	103	98	16	66	do			Stock		
2278	do	do	H-6	1885?	Bored, 4-inch	103		100?	32	Wind			Domestic		
2279	Sam. Franklin	do	H 8	1879?	Driven, 5-inch	105		50?	35	Hand			do		
2280	J Y Stephenson	do	H 6	1882?	Driven, 6-inch	104		50?	42	do			do		
2281	Mrs B Frankel	do	H 6	1895?	Driven, 4-inch	108		80	48	do	75.00		Domestic; stock		
2282	N Vanfleet	Los Coyotes	H-5	1883	Bored, 7-inch	112	112	277	26	Wind, gas	500.00	250.00	Domestic; irrigation		20
2283	do	Santa Gertrudis	H-5	1880?	do	112	106	325					Not used		
2284	W F Hall	do	H-5	1903	Bored, 4-inch	112	107	81	33	Hand	75.00		Domestic; stock		
2285	W H Townsend	do	H-6	1888	do	112	107	42	27	do	40.00		Domestic		
2286	Mrs Husk	do	H 6	1885	do	113	108	64	29	do	50.00		do		
2287	R B Carpenter	do	G-5	1902	Bored, 1½-inch	114		32	29	do	20.00		do		
2288	I R Crowell	do	G-5	1898	Bored, 2-inch	114		86	30	Wind	42.00	125.00	Domestic; stock		
2289	R B Carpenter	do	G-5	1900	Bored, 10-inch	114	108	100	25	Gas	250.00		Irrigation		35
2290	do	do	G-5	1888?	Bored 4-inch	109		65	31	Wind	52.00		Domestic; stock		
2291	P O Rogers	do	G-5	1887	do	110	104	70	33	do	56.00	240.00	Domestic		
2292	J. E. Jannison	do	G-6	1887	do	107	100	65	33	do	52.50		Domestic; stock		
2293	J. H. Cooke	do	G-6	1885	do	99	92	92			60.00		Not used		
2294	R E. Briar	do	G-6	1879?	do	97	91	60	25	Wind			Domestic; stock		
2295	Redfield Chatman	do	F-6	1880?	do	103	91	100?	21	do			do		
2296	J Quill	do	F-6	1884?	do	100		117	22	Hand	125.00		Domestic		
2297	Mrs. Hewitt	do	G-6	1898	Bored, 2-inch	99		90		do			do		
2298	A Horton	do	G-6		do	98		90?	26	do			do		
2299	Joe Dismukes	do	F-6		Driven, 2-inch			20?		do			Stock		
2300	H. A. Anderson	do	G-7		Bored, 4-inch	93		85?	22	Wind			Domestic		
2301	A. Curtain	do	F-7	1885	do	95		114	24	do	100.00	50.00	do		

Wells in the Downey quadrangle—Continued.

Number of well.	Owner	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
2302	A Curtain	Santa Gertrudis	F 6	1900	Bored, 12-inch	95	96	755	23	Artesian	$2,360.00		Irrigation	Small.
2303	Wm. McCormick	do	F-6	1903	Bored, 5-inch	96	86	125	28	Hand	120.00	$27.00	Domestic	
2304	A Curtain	do	F 6	1895	Bored, 2-inch	95	85	110	22	do	40.00		Stock	
2305	Downey Masons	do	G 7	1896?	Bored, 4-inch	93				Wind			Irrigation	
2306	T. S. Beatty	Los Cerritos	G 7	1889	Bored, 10-inch	92	84	237		Gas	650.00	700.00	do	
2307	do	do	F 7	1883?	Bored, 4-inch	92		90?	26	Wind			Domestic	
2308	John Mullen	do	F 7	1898	Bored, 12-inch	89		190					Irrigation	
2309	do	do	F 7	1903	Bored, 5-inch	88		150?	26	Wind			Domestic	
2310	Mrs. Petterson	do	G 7	1892	Bored, 4-inch	84	80	118	24	do			do	
2311	G. Anderson	do	F 7	1898	Bored, 9½-inch	84	80	237		Gas	360.00	700.00	Irrigation	90
2312	do	do	F 7	1903	Bored, 10-inch	84	80	237		do	350.00			
2313	F. Caseres	do	F 7	1900	Bored, 2-inch	84	81	150	26	Hand	45.00	125.00	Domestic	
2314	G. Anderson	do	F 7	1891	Bored, 7-inch	84		233	25	Wind	300.00	120.00	Domestic; stock	
2315	Fred Lechner	do	F 7	1902	Bored, 5-inch	84	84	129		Wind, artesian	150.00		do	Small.
2316	Chas. McCurdy	do	F 7	1898	Bored, 2-inch	83	83	155		Hand	62.00		Domestic	
2317	H. Bush	do	F 7	1883?	Bored, 4-inch	82	78	110	28	do	88.00		do	
2318	A. Convert	do	F 7	1895	Bored, 2-inch	82	82	137		Artesian	55.00		do	Small.
2319	do	do	F 7	1898	do	82	82	142	25	do	60.00		Stock	1½
2320	do	do	F 7	1902	do	81	81	96	26	do	40.00		Domestic	Small.
2321	D. O'Leary	do	F 7	1893	do	80	80	140	25	Artesian, hand	55.00		Domestic; stock	Small.
2322	F. W. Curtis	do	F-7	1901	Bored, 5-inch	81		151	24	Hand	125.00		Domestic	
2323	Mr. Armstrong	do	F 8	1899	Bored, 2-inch	79	79	146	24	Artesian, hand	55.00		Stock; domestic	Small.
2324	E. L. Lovel	do	F 8	1898	do	78	78	630	25	Artesian	224.00		Domestic; irrigation	4

2325	.....do.....	.....do.....	F-8.....	1899	.....do.....	77	77	130	25	Artesian, hand .	48.00	.....	Stock.....	Small.
2326	L. Ofer.....	.....do.....	F-8.....	1903?	.....do.....	77	77	140?	26	Artesian.....	.....	.....	Domestic; stock.	.....
2327	L. Conant.....	.....do.....	F-8.....	1893?	.....do.....	75	75	138	24	Artesian, wind .	50.00	.....	Domestic.....	Small
2328	Chris. Miller	.....do.....	F-8.....	1900	.....do.....	72	72	155?	24	Artesian.....	50.00	.....	Stock; irrigation	1½
2329	.....do.....	.....do.....	F-8.....	1895	.....do.....	72	72	150	24	.....do.....	40.00	.....	Domestic; stock.	.....
2330	Mr. Fitzpatrick.....	.....do.....	F-8.....	1901	.....do.....	72	.....	150?	24	.....do.....	40.00	.....	.....do.....	1
2331	Axle Anderson.....	.....do.....	F-8.....	1899	Bored, 3-inch.....	71	71	160	25	.....do.....	36.00	.....	Domestic; stock; irrigation	1
2332	A. J. Staly.....	.....do.....	F-8.....	1894?	.....do.....	70	70	144	24	.....do.....	70.00	.....	Domestic; stock.	.....
2333	.....do.....	.....do.....	F-8.....	1897?	.....do.....	70	70	140	.....	.....do.....	75.00	.....	Irrigation; stock	.....
2334	John Anderson.....	.....do.....	F-9.....	1900	Bored, 10-inch....	68	68	675	24	.....do.....	1,400.00	.....	Irrigation.....	.....
2335	M. N. Pousey.....	.....do.....	F-9.....	1896	Bored, 2-inch.....	69	69	205	27	.....do.....	83.00	.....	Domestic.....	Small.
2336	John Anderson.....	.....do.....	F-9.....	1894	.....do.....	69	69	260	.....	.....do.....	110.00	.....	Not used.....	.....
2337	.....do.....	.....do.....	F-9.....	1895	.....do.....	69	69	260	26	.....do.....	110.00	.....	Domestic.....	Small
2338	C. P. Eldridge.....	.....do.....	F-9.....	1896	Bored, 3-inch.....	70	70	610	24	.....do.....	150.00	.....	.....do.....	.....
2339	P. H. Clark.....	Santa Gertrudis..	F-9.....	1891?	.....do.....	71	71	248	24	Artesian, wind .	.....	.....	.....do.....	Small.
2340	C. H. Kirby.....	Los Cerritos.....	E-9.....	1896?	Bored, 2-inch.....	64	64	500	24	Artesian.....	224.00	.....	Domestic; stock.	Small.
2341	.....do.....	.....do.....	E-9.....	1898	.....do.....	64	64	168	24	.....do.....	.....	.....	Irrigation.....	2
2342	.....do.....	.....do.....	E-9.....	1898	.....do.....	64	64	178	26	.....do.....	65.00	.....	.....do.....	†1
2343	.....do.....	.....do.....	E-9.....	1892?	Bored, 4-inch.....	64	67	145?	25	.....do.....	.....	.....	Stock.....	Small.
2344	J. D. Fredericks.....	.....do.....	F-9.....	1898	Bored, 2-inch.....	65	65	588	33	.....do.....	235.00	.....	Stock; domestic.	.....
2345	A. I. Stewart.....	.....do.....	E-9.....	1901	.....do.....	65	65	190	24	Artesian, hand .	80.00	.....	Domestic.....	Small.
2346	.....do.....	.....do.....	E-9.....	1894?	Bored, 4-inch.....	66	66	600?	24	Gas.....	350.00	.....	Irrigation.....	.....
2347	J. H. Patterson.....	.....do.....	F-9.....	1899?	Bored, 3-inch.....	66	66	760?	27	Artesian.....	.....	.....	Domestic; irrigation.	.....
2348	A. McKelvey.....	.....do.....	E-9.....	1898	Bored, 2-inch.....	68	68	226	25	Hand.....	90.00	.....	Domestic.....	.....
2349	J. C. Caldwell, agent..	.....do.....	E-9.....	1902	.....do.....	69	69	554	24	Artesian.....	250.00	.....	.....do.....	2
2350	Mrs. A. Blanc.....	.....do.....	F-9.....	1899	Bored, 4-inch.....	69	69	630?	26	.....do.....	.....	.....	Domestic; irrigation.	5
2351	Alex. Stewart	.....do.....	F-9.....	1897	Bored, 2-inch.....	69	69	630	24	.....do.....	120.00	.....	.....do.....	.....
2352	C. H. Longhery.....	.....do.....	E-9.....	1901	.....do.....	70	70	182	24	Wind.....	82.00	.....	Domestic.....	.....
2353	H. P. Epperson.....	.....do.....	E-8,9...	1895	.....do.....	70	70	300	24	Artesian, wind .	300.00	.....	.....do.....	Small.
2354	.....do.....	.....do.....	E-8.....	1895	.....do.....	70	70	616	23	Artesian.....	300.00	.....	.....do.....	.....
2355	.....do.....	.....do.....	E-8,9...	1895	.....do.....	70	70	615	.....	.....do.....	300.00	.....	.....do.....	.....
2356	T. F. Downs.....	.....do.....	F-8.....	1903	.....do.....	70	70	140	21	Hand.....	60.00	.....	.....do.....	.....
2357	John Clark.....	.....do.....	F-8.....	1898	.....do.....	70	70	140	25	.....do.....	60.00	.....	.....do.....	.....

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
2358	Hynes Irrigation Co.	Los Cerritos	E-8	1898	Bored, 12-inch	71	71	253	22	Gas		$700.00	Irrigation	†100
2359	E. T. Thwing	do	E-8	1899	Bored, 2-inch	72	72	615	25	Artesian	$180.00		Domestic	
2360	M. A. Pilkey	do	E-8	1896?	do	72	72	150	26	do	65.00		do	
2361	J. Jahnke	do	E-8	1903	do	72	72	145		Hand	65.00		do	
2362	Mrs. Letner	do	E-8	1903	do	72	72	147	25	Artesian	67.00		do	
2363	Chas. Harman	do	F-8	1897?	Dug, 3 by 3 foot	73	67	8	53	Hand			do	
2364	E. T. Fuller	do	F-8	1895	Dug, 2 by 3 foot	73	67	7	50	do			do	
2365	H. L. Covell	do	F-8	1896?	Bored, 2-inch	73	73	150		Artesian, hand	65.00		do	
2366	do	do	F-8	1898	do	73	73	150	24	Hand, artesian	65.00		do	
2367	F. F. Howard	do	F-8	1893	Bored, 4-inch	73	73	150	25	do	150.00		Domestic; stock	Small.
2368	Mrs. Chas. Wilds	do	F-8	1899	Bored, 2-inch	74	74	150	24	Artesian	65.00		do	2
2369	John Steneman	do	F-8	1897	do	73	73	150	22	Hand, artesian	50.00		Domestic; irrigation.	Small.
2370	Mrs. Thompson	do	F-8	1900?	do	73	73	135	23	Artesian			Domestic	
2371	G. W. Williams	do	F-8	1895	do	73	73	148	24	Artesian, hand	60.00		do	1
2372	J. F. King	do	E-8	1897	do	73	73	146	25	Artesian	55.00		Domestic; stock	2
2373	Mrs. G. Geryalva	do	F-8	1901	Dug, 3 by 3 foot	74	68	8		Hand			Domestic	
2374	Chas. Wilder	do	F-8	1901	Bored, 2-inch	74	74	152	25	Artesian			Domestic; stock	†1
2375	G. E. Robdin	do	F-8	1897	do	75	75	160	24	do	63.50		Domestic	Small.
2376	School	do	F-8	1893	do	75	75	152	22	Wind	65.00	125.00	do	
2377	W. M. Squires	do	F-8	1895?	do	75	75	165	24	Artesian	70.00		do	†1
2378	J. Q. Hall	do	E, F-8	1897	do	74	74	160	25	Hand	64.00		do	
2379	Mrs. Gaines	do	F-8	1895?	do	74	74	154	24	Artesian				

2381	J. B. Smith	do	E-8	1901	Dug, 2½ by 2½ foot	72	68	6	65	Hand			Stock	
2382	A. L. Austin	do	E-8	1896	Bored, 1½-inch	73	73	157	27	Artesian, hand	60.00		Domestic	Small.
2383	T. F. Stansberry	do	E-8	1897?	Bored, 2-inch	74	74	365	24	Artesian	230.00		Irrigation	Small.
2384	do	do	E-8	1894?	Bored, 7-inch	74	74	287	24	Wind, artesian	390.00	75.00	Irrigation; domestic.	Small.
2385	A. E. Chapman	do	E-8	1893?	Bored, 3-inch	74	73	160	24	Hand			Domestic	
2386	W. T. Carter	do	E-8	1895	Bored, 2-inch	74	73	217	24	do	90.00		do	
2387	do	do	E-8	1895	do	74	74	165	23	Hand, artesian	65.00		do	Small.
2388	A. Perkins	do	E-8	1903	do	74	74	159	25	Hand	65.00		do	
2389	James Hill	do	E-8	1901	do	75	75	168	23	Wind	65.00		do	
2390	Mrs. Kingston	do	F-8	1889	Driven, 1½-inch	75		14	46	Hand			do	
2391	E. A. Rogers	do	E-8	1886?	Bored, 7-inch	77	76	190	24	Wind	380.00	75.00	do	
2392	do	do	E-8	1898	Bored, 2-inch	77	77	176	23	Artesian	80.00		Irrigation	2
2393	W. C. Thomas	do	E-8	1901	do	75	75	153	25	do	65.00		Domestic	Small.
2394	Mr. Patterson	do	E-8	1899?	do	75		140?	25	Wind	55.00		do	
2395	D. R. Bell	do	E-8	1903	do	75	75	156	26	Hand	65.00		do	
2396	W. Malcom	do	E, F-8		do	75		90?		do			do	
2397	Geo. Spafford	do	E, F-8	1902	do	75	75	177	33	Artesian, hand	70.00	10.00	do	Small.
2398	Geo. H. Meissen	do	F-8	1903	Bored, 7-inch	76	76	142	27	Artesian	284.00		Irrigation	5
2399	do	do	F-8	1902	Bored, 2-inch	76	76	168	25	do	75.00		Domestic	1
2400	I. A. Sharp	do	F-8	1893	do	77	77	135	25	Artesian, hand	60.00		Domestic; stock	Small.
2401	do	do	F-8	1900	Bored, 4-inch	77	77	140	22	Artesian	110.00		Irrigation	†3
2402	Theo. Ice	do	F-8	1899	Bored, 2-inch	77	77	144	22	do	45.00		Stock	1½
2403	do	do	F-8	1900	do	77	77	171		do	51.00		do	†2
2404	do	do	F-8	1892?	Bored, 7-inch	78	78	163	24	Hand			Domestic; stock	Small.
2405	R. R. Briggs	do	F-7	1890?	Bored, 4-inch	80	80	150?	25	Wind			do	
2406	I. Mitchler	do	E-7	1897	Bored, 2-inch	79	79	144	26	Artesian, hand	60.00		Domestic	†2
2407	Robert A. King	do	E-7	1896	do	82	82	156	24	Wind, artesian	60.00		do	Small.
2408	F. Ealey	do	E-7	1897	do	82	82	144	27	Hand, artesian	50.00		do	Small.
2409	Mr. McClure	do	E-7	1888	Bored, 6-inch	83	83	160	25	Wind			Domestic; stock	
2410	P. Bohn	do	E, F-7	1890?	Bored, 2-inch	84	84	140	26	Hand	55.00		Domestic	
2411	do	do	F-7	1901	Bored, 12-inch	87	87	158	25	Gas, artesian	450.00	775.00	Irrigation	†60
2412	D. Gemmill	do	F-7	1894	Bored, 2-inch	88	88	134	26	Hand	60.00		Domestic	
2413	do	do	F-7	1896	do	88	88	150		do	50.00		Stock	
2414	do	do	F-7	1896	do	88	88	150	25	Artesian	50.00		do	Small.

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
2415	Mr. Bacon	Santa Gertrudis	F-6	1893	Bored, 7-inch	95	95	300?	27	Wind			Stock	
2416	do	do	F-6	1883?	do	96	94	109	26	Hand			do	
2417	D. Lane	do	F-6	1899	Bored, 2-inch	97	92	140	29	Wind	$100.00		Domestic; stock	
2418	G. W. Holcomb	do	F-6	1895?	Bored, 4-inch	100	92	110	28	do	55.00		Domestic	
2419	J. W. Venable	do	F 6	1876	do	100	92	68	29	do	33.00	$50.00	do	
2420	M. McCurdy	do	F-6	1898?	Driven, 1½-inch	101		16	36	Hand			do	
2421	C. Brown	do	F-6	1887	Bored, 7-inch	102	94	100	27	Wind			do	
2422	Thos. Grider	do	F 6	1898	Driven, 1½-inch	102		85	30	Hand	40.00		do	
2423	do	do	F-6	1880	Dug, 2½ by 2½ foot	102	92	14	53	do			Stock	
2424	J. W. Brown	do	F-6	1889	Bored, 4-inch	103		112	30	Wind	112.00	50.00	do	
2425	James Quill	do	F 6	1883	do	103		125	28	do			Domestic	
2426	do	do	F-5	1883	do	103		85	29	Hand			Stock	
2427	do	do	F-6	1883	do	104	91	98	23				Not used	
2428	B. L. Barnett	do	F-6	1893	do	104	91	160?	29	Wind			Domestic	
2429	C. B. Reddick	do	F-5	1893?	Driven, 1½-inch	106		60?	43	Hand			do	
2430	Mrs. Clayton	do	F-6	1888	Bored, 4-inch	105	91	85?	32	Wind			do	
2431	J. H. Cooke	do	F-6	1884	do	105	92	86	28	do	60.00		do	
2432	Mrs. Briggs	do	F-6	1896?	Bored, 5-inch	105	94	98	26	do			do	
2433	J. De Plaa	do	F-5		Dug, 2 by 3 foot	106	96	12		Hand			do	
2434	L. L. Easterly	do	F-6		Driven, 1½-inch	106		35?	32	do			do	
2435	J. H. Aldis	do	F-5	1891?	Bored, 4-inch	107		90	30	Wind			do	
2436	Chas. Butler	do	F-6		do	106	95	75	26	Hand			do	
2437	Mr. Cookingham	do	G-6	1896	Bored, 2-inch	107		97		Wind	48.00	60.00	do	

2438	J. Ullery	do	G-6	1888	Bored, 4-inch	107	96	105	28	do	70.00	65.00	do
2439	Mrs. T. J. Kearns	do	G-6	1882	do	106	96	86	46	do	70.00		do
2440	Mrs. J. Butler	do	G-6	1882	do	107		88	29	Hand	70.00		do
2441	F. Bohn	do	G-6	1901	do	103		100	27	Wind	73.00	150.00	do
2442	do	do	G-6	1882	do	103		90	27	do			Stock
2443	Alameda School	do	G-6	1899	do	104		86	26	Hand			Domestic
2444	B. P. Patten	do	G-5	1896	Dug, 2-foot diam	110		82	28	do	40.00		do
2445	F. Stout	do	G 5	1885?	Driven, 2-inch	110		76		do			do
2446	B. P. Patten	do	G 5	1885?	Bored, 4-inch	111		86	28	do	65.00		do
2447	R. B. Alexander	do	G 5	1897	Hydraulic, 2-inch	112		78	33	Wind	27.00		do
2448	A. Buhler	do	G 5	1875?	Bored, 6-inch	112	98	108	29	do			do
2449	F. Smith	do	G 5	1898?	Bored, 2-inch	113		82	32	Hand			do
2450	W. W. Walk	do	G 5	1893	Driven, 1¼-inch	114		87	33	do	40.00		do
2451	G. W. Snyder	do	G 5	1889	Bored, 4-inch	114	104	86	30	Wind	40.00		do
2452	Erven Gillies	do	G 5	1899	do	114		86	30	Hand	70.00		do
2453	L. F. Jones	do	G 5	1901	Bored, 2-inch	115		87	27	do	65.00		do
2454	O. P. Towne	do	G 5	1880?	Dug, 2½ by 2½ foot	115	108	10	51	do			do
2455	do	do	G-5	1880?	Dug, 2½ by 3 foot	116	108	11	200+	do			Stock
2456	M. E. Scummins	do	G-5	1885	Bored, 2-inch	115		76	34	do			Domestic
2457	A. B. Walk	do	G-5	1901	Bored, 4-inch	115		84	35	do			do
2458	Miss Knight	do	G 5	1902?	do	114	104	80	28	do			do
2459	John McCommie	do	G-5		do	114		80	28	do	60.00		do
2460	Mr. Graham	do	G-5	1887?	do	114		83	31	do	64.00		Domestic; stock
2461	A. M. Thompson	do	G-5	1902	do	115	105	96	30	Wind	62.00	40.00	Domestic
2462	Mrs. Weis	do	G-5	1884	Bored, 7-inch	116	105	90	29	Steam			Winery
2463	do	do	G-5	1887	do	115	105	90	29	Wind			Domestic
2464	John Stewart	do	G-5	1888	Bored, 4-inch	117		96	31	Hand	90.00		do
2465	do	do	G-5	1894?	Bored, 2-inch	115		88	31	do			do
2466	J. H. Strine	do	G-5	1883	Bored, 4-inch	115	105	90	28	do	70.00		do
2467	W. J. Snyder	do	G-5	1903	Bored, 5-inch	115	105	87	26	do	88.00		do
2468	W. W. Bramlett	do	G-5	1903	Bored, 7-inch	115	105	87	28	do	110.00		do
2469	Mrs. Houston	do	G-5	1888	Bored, 4-inch	114		86	26	do			do
2470	A. J. Bramlett	do	G-5	1891	Bored, 2-inch	114		90	31	do	45.00		do
2471	R. M. Moore	do	G-5	1887	Bored, 4-inch	115	113	96	30	do	72.00		do
2472	J. W. Woolliscroft	do	G-5	1898	do	113	103	91	28	Wind	70.00		do

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
2473	H. A. Scott	Santa Gertrudis	G-5	1888	Bored, 4-inch	111	100	96	29	Wind	$78.00	$75.00	Domestic	
2474	E. A. Brunson	do	G-5	1902	do	109	99	96	39	Hand	78.00		do	
2475	do	do	G-5	1896	Hydraulic, 1½-inch	110		109	30	do	50.00		Stock	
2476	L. Ullery	do	G-5	1888	Driven, 1¼-inch	189		16	86	do	7.00		Domestic	
2477	H. A. Mosher	do	G-5	1899	Bored, 4-inch	109	98	77	29	do	58.00		do	
2478	M. L. Holcom	do	G-5	1899	Driven, 1¼-inch	109		29	38	do			do	
2479	J. C. Ullery	do	G-5	1900	Bored, 2-inch	108		96	28	do	45.00		do	
2480	S. A. Wayne	do	F-5	1888?	Bored, 4-inch	109		90	29	Wind	70.00		do	
2481	H. H. Felch	do	F 5	1883?	Bored, 5-inch	108	95	74		Hand			Domestic; stock	
2482	E. P. Dismukes	do	F 5	1902	Bored, 4-inch	107	97	84	27	do	68.00		Stock	
2483	C. F. Mackley	do	F 5	1895	Bored, 2-inch	109		90	30	do	45.00		Domestic	
2484	T. F. Renfro	do	F, G-5	1888	Bored, 4-inch	110	100	19	51	Wind	16.00		Stock	
2485	do	do	G-5		Driven, 1¼-inch	110		20	69	Hand			Domestic	
2486	Dr. J. C. Kendrick	do	F 5	1888	do	111		19	34	do	8.00		do	
2487	do	do	F 5	1901	Dug, 3 by 6 foot	111	102	10	56	do			Stock	
2488	E. P. Dismukes	do	G-5	1900	Hydraulic, 2-inch	113		96	30	Wind	45.00		do	
2489	D. E. Darrow	do	G-5	1888	Bored, 4-inch	113	104	85	29	do	80.00	150.00	Domestic	
2490	P. F. Ryan	do	G-5	1898?	Driven, 1¼-inch	113		20	40	Hand			do	
2491	Wm. Bischoff	do	G-5	1902	Driven, 4-inch	114	107	16	25	do	18.00		do	
2492	F. Dubio	do	G-5	1900	Bored, 4-inch	115	105	96	31	do	75.00		Domestic; stock	
2493	O. E. Gunter	do	G-5	1894?	do	115	107	19	27	do	15.00		Domestic	
2494	Mrs. Wilson	do	G-5	1900	do	116		18	28	do	16.80		do	
2495	do	do	G-5	1901	do	116	107	20	37	do	19.00		Stock	

2496	L. N. Zahrt	do	G-5	1901	do	116		92	29	do	70.00		Domestic	
2497	do	do	G-5	1895?	Driven, 1½-inch	116		60	41	do	10.00		Stock	
2498	W. H. Mather	do	G-5	1901	Bored, 5-inch	117		96	33	do	75.00		Domestic	
2499	Chas. E. Smith	do	G-5	1898	Bored, 4-inch	117		92	30	Wind	65.00	60.00	do	
2500	H. D. Huggins estate	do	G-5	1894?	do	116		94	29	Hand	80.00		do	
2501	O. Moores	do	F-4	1897	Hydraulic, 2-inch	114		90?	29	do			do	
2502	H. Hood	do	F-5	1903	Bored, 5-inch	114		94	30	do	85.00		do	
2503	T. R. Bagley	do	F-5	1903	do	111	105	97	29	Wind	92.00	35.00	Domestic; stock	
2504	do	do	F-5	1884	Driven, 1½-inch	111		23	22	Hand			Domestic	
2505	O. T. Stoube	do	F-5	1899	Bored, 10-inch	111	103	120		Steam	210.00	535.00	Irrigation	†80
2506	do	do	F-5	1899	Hydraulic, 3-inch	111		88	28	Hand	55.00		Domestic	
2507	E. M. Allen	do	F-5	1890	Bored, 4-inch	112		87	30	do	65.00		do	
2508	R. E. Taylor	do	F-5	1903	Bored, 5-inch	110		98	67	do	95.00		do	
2509	J. R. Wright	do	F-5	1885?	Bored, 4-inch	110		96	27	Wind	70.00		do	
2510	W. W. Wright	do	F-5	1898	do	110	100	98	29	do	75.00		do	
2511	J. E. Parker	do	F-5	1896?	do	108		102	29	do	72.00		Domestic; stock	
2512	E. P. Dismukes	do	F 5	1888	do	108	99	98	28	do	76.00		do	
2513	S. M. Adams	do	F-5	1901	do	107	97	98	47	Hand	75.00	14.00	Domestic	
2514	J. G. Slingerland	do	F-5	1894?	do	106	97	93		Wind	70.00	40.00	do	
2515	E. L. Vaughn	do	F-5	1897	Bored, 2-inch	112		103	33	Hand	40.00		do	
2516	do	do	F-5	1903	Dug, 3 by 3 foot	109	104	12	91	do	19.00		Stock	
2517	N. G. Thomas	do	F-5	1891	Bored, 2-inch	107		97	32	do	45.00		Domestic	
2518	Mrs. J. T. Saunders	do	F-5	1882?	Bored, 4-inch	106	91	50	26	Wind			Domestic; irrigation	
2519	Geo. Leeritz	do	F-5	1902	do	103		98	26	Hand	78.00		Domestic	
2520	Mr. Janka	do	F-5		Bored, 2-inch	102		101	26	Wind			do	
2521	R. P. Young	do	F-5	1887?	Dug, 3 by 3 foot	100	92	12	62	Hand			do	
2522	County Farm	do	F-5		do	98	92	8	47	do			Stock	
2523	P. Mussachie	do	F-5	1901	Bored, 4-inch	99	93	87	25	do	67.00		Domestic	
2524	W. M. Mansfield	do	F-5	1901	Bored, 2-inch	99		100	24	do	45.00		do	
2525	A. Monteleone	do	F-5	1884	Bored, 4-inch	98	92	100	24	do	105.00		do	
2526	do	do	E, F-5	1884	do	97		115	25	Wind	110.00		Domestic; stock	
2527	Old River School	do	F-5	1889?	do	98	92	110	27	Hand	80.00		Domestic	
2528	Mrs. L. S. Clayton	do	F-5	1898?	do	102	94	92	29	Wind			do	
2529	County Farm	do	F-6	1896?	Bored, 12-inch	101	92	178	28	Compressed air	*2,000.00		Irrigation	†100

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
2530	W. A. Horton	Santa Gertrudis	F-6	1891	Bored, 7-inch	98	90	126	27	Wind		$45.00	Domestic	
2531	County Farm	do	E-6	1888?	do	93	89	185	29	Gas			Domestic; irrigation.	†4
2532	Geo. L. Rognon	do	E-5	1901	Bored, 4-inch	98	94	106	26	Hand	$74.00	8.00	Domestic	
2533	Salt Lake terminal	do	E-5	1903	Bored, 2-inch	99		80		do			do	
2534	E. Gunn	do	E-5	1903	Bored, 12-inch	102	94	280	24	Gas			Irrigation	180
2535	do	do	E-5	1903	do	102	94	280		do			do	
2536	do	do	E-5	1903	do	102	94	280					do	
2537	Mrs. Wyatt	do	E-4	1896	Bored, 2-inch	112		140	35	Wind	60.00		Domestic	
2538	T. A. House	San Antonio	E-4	1880?	Bored, 4-inch	108	103	84	24	Hand	80.00		do	
2539	do	do	E-4,5	1880?	Bored, 6-inch	105	105	260	27	do			Stock	
2540	S. P. Walser	do	E-4	1903	Bored, 5-inch	108	102	127	24	do	121.00		Domestic	
2541	H. H. Davis	do	E, F 4	1880?	Bored, 4-inch	112	105	76	27	Wind	60.00		do	
2542	John Grant	do	F-4	1885?	Bored, 3-inch	113		100	23	Hand			Domestic; stock	
2543	J. A. Stewart	Santa Gertrudis	E, F-4	1884	Bored, 4-inch	108		92	28	Wind	75.00		Domestic	
2544	J. H. Fairbanks	do	F-5	1887	do	107	98	86	25	do	72.00		do	
2545	Robert Johnson	do	F-4	1888?	do	108	101	84	26	do	68.00		do	
2546	B. M. Curtis	do	F-4	1901	do	109	101	80	28	Hand	65.00		do	
2547	do	do	F-4	1883	Dug, 2½ by 2½ foot	109	101	10		do			Stock	
2548	O. T. Stroube	do	F-4	1904	Bored, 12-inch	112		417	31	Artesian?	800.00		Not used	
2549	Jim Wiley	do	F-4	1897	Hydraulic, 2-inch	111		100	23	Wind	45.00		Domestic; stock	
2550	Mrs. Laubersheimer	do	F-4		Bored, 7-inch	114	108	46	22	Hand			Domestic	
2551	J. T. Barnett	do	F-4	1899	Bored, 4-inch	114		80	31	Wind	65.00	45.00	Stock; domestic	
2552	J. C. Simmons	do												

2553	Ida Maulhart	do	F-4	1897	do	120	113	87	26	Wind	68.00		do		
2554	C. S. Williams	do	F, G-4	1898	Bored, 2-inch	122		68	27	do	35.00		do		
2555	Mrs. Jackson	do	G-4	1899	Dug, 3 by 4 foot	125	115	12	56	Hand			do		
2556	Barnett Bros	do	G-3	1897	Bored, 2-inch	124		90	28	do	38.00		do		
2557	H. H. Hunt	do	F, G-3	1896	Hydraulic, 2-inch	123		75	30	Wind	30.00	40.00	do		
2558	Fred Wells	San Antonio	F-3		Dug, 2½ by 2½ foot	122	118	9	61	Hand			do		
2559	Y. Rhodes	do	F-3	1883	Dug	122	117	7	34	do			do		
2560	M. Paxton	do	F-3	1893	Driven, 1¼-inch	123		17	37	do			do		
2561	J. S. Perry	do	F-3	1898	Bored, 2-inch	122		80	23	do	40.00		Domestic; stock		
2562	J. Solomon	do	F-3	1888?	Bored, 4-inch	122		100	24	do			Domestic		
2563	Wm. Harper	do	F-3	1899	Bored, 12-inch	120	114	130		Gas	250.00	800.00	Irrigation	†75	
2564	do	do	F-4	1895?	Bored, 2-inch	118		106	24	Wind			Domestic		
2565	R. B. Harper	do	F-4	1899	Bored, 4-inch	117	109	104	23	do	90.00		Domestic; stock		
2566	Grant Bros	do	E-4	1895	do	116	110	96	22	Hand			Domestic		
2567	T. N. Ellis	do	E-3	1878?	Bored, 7-inch	120		335	24	Wind			do		
2568	N. E. Fay	do	E-3	1875?	Bored, 6-inch	122		180	34	do			do		
2569	do	do	E-3	1903	Bored, 10-inch	124	118	221		Steam	400.00		Irrigation	†80	
2570	A. Leach	do	E-3	1902	Bored, 5-inch	122	116	101	29	Hand	91.00		Domestic; stock		
2571	San Antonio School	do	E-3, 4		Bored, 7-inch	121	119	35	31	do			Domestic		
2572	H. G. Hamilton	do	E-4	1892?	Bored, 2-inch	121		285	34	do			do		
2573	do	do	E-4	1903	Bored, 5-inch	121	118	360	35				Not used		
2574	J. Clements	do	E-4	1888	do	120		100	37	Hand	90.00		Domestic		
2575	Lewis Gross	do	D-4	1904	Bored, 12-inch	118	112	185	71	Not installed	370.00		Irrigation		
2576	do	do	E-4	1901	Bored, 2-inch	118		127	36	Hand	55.00		Domestic		
2577	K. Mosbacher	do	E-4	1902	do	116		145	37	Wind	74.00	35.00	do		
2578	D. Barberena	do	E-3	1883	Bored, 4-inch	121	114	44	46	Hand			do		
2579	M. M. Shirley	do	F-3	1880	do	123	116	52	27	do	68.00		do		
2580	Z. B. Slater	do	F-3	1880?	do	124		62	32	Wind			do		
2581	T. H. Stafford	do	F-3	1899	Bored, 7-inch	124	116	64	26	do	85.00		do		
2582	Wm. Specht	do	F-2	1893	do	135	125	99	28	do	100.00	150.00	do		
2583	do	do	F-2	1883	Dug, 3 by 4 foot	132	123	15	48	Hand			do		
2584	do	do	E-2	1899	Bored, 10-inch	130	125	200	36		250.00		Not used		
2585	do	do	E-2	1899	do	130	128	860	38	Gas	3,000.00	950.00	Irrigation	†90	
2586	H. T. Shirley	do	E-2	1900	Bored, 2-inch	133		230	37	Wind	110.00	40.00	Domestic; stock		
2587	L. A. Walker	do	E-2	1902	Bored, 10-inch	138	130	428	38	Gas	1,000.00		Irrigation	†100	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
2588	Robert Brown	San Antonio	D-2	1886?	Bored, 7-inch	142		320	36	Wind			Domestic	
2589	W. Partridge	do	D, E-2	1898	Bored, 2-inch	139		104	38	do	$36.00		do	
2590	Doctor Royer	do	D-3	1903	Bored, 10-inch	137	128	103	37	Gas			Irrigation	†20
2591	Mrs. Summers	do	D-2	1897?	Bored, 7-inch	143	134	27	....	Wind			Domestic	
2592	W. J. Jones	do	D-2	1885?	Dug, 3 by 4 foot	144	135	13	58	Hand			Stock	
2593	C. Rathole	do	D-3	1885?	Bored, 7-inch	139		106	38	Wind	105.00	$90.00	Domestic; stock	
2594	Mrs. Baker	do	C-1		Dug, 4 by 4 foot	176	158	19	56	Hand			Domestic	
2595	do	do	C-1		Bored, 7-inch	178		60	53	do			do	
2596	E. G. Greening	do	D-1		Dug, 2½ by 2½ foot	175	157	19	86	do			Stock; domestic	
2597	do	do	D-1	1899	Bored, 10-inch	163	153	181	39	Electricity	328.00		Irrigation	†195
2598	do	do	D-1	1896	Bored, 4-inch	150		60	44	Horsepower			Domestic; stock	
2599	do	do	D-2	1890?	Dug, 4 by 4 foot	162	148	14	150	Hand			Domestic	
2600	do	do	D-2	1901	Bored, 4-inch	150		71	42	do	28.00		do	
2601	Mrs. Baker	do	D-2	1880?	Dug, 3 by 3 foot	149	138	12	31	do			do	
2602	Pacific Electric Co	do	F-2	1903	Bored, 4-inch	143		90	28				do	
2603	Mrs. Baker	do	G-1,2	1902	Dug, 4 by 4 foot	162	138	26	46	Wind			Domestic; stock	
2604	do	do	F-1	1893	do	148	141	10	25	do			Domestic	
2605	do	do	F-1	1876?	Bored, 6-inch	146	142	510	52				Stock	†2
2606	do	do	F-1	1900	Bored, 10-inch	149	142	600–	52	Gas				†10
2607	Thomas Hodgins	do	G-2	1903	Bored, 7-inch	155	130	121	32	Wind			Domestic	
2608	H. T. Gage	do	G-3	1890?	do	141		150	29	Gas			do	
2609	B. Mendia	do	F-2	1887	Dug, 4 by 4 foot	137	122	16	29	Wind			do	

2610	A. Ducos	do	F-2	1901	Bored, 8-inch	137		20	43	do			do
2611	C. S. Walton	do	F-2	1895	Bored, 4-inch	137		63	34	do			do
2612	P. Lugo	do	F-2	1897	Dug, 3 by 3 foot	127	138	11	61	Hand			do
2613	F. N. Lugo	do	F-2	1875?	Dug, 2 by 2 foot	136	124	13	53	do			do
2614	H. Reich	do	F-2	1864?	Dug, 2 by 4 foot	136	124	16	28	Wind			Domestic; stock
2615	Chas. Dochtermann	do	F 2	1898	Dug, 4 by 4 foot	135	125	12	35	Hand			do
2616	E. Peschkt	do	F, G 3	1893?	Bored, 7-inch	131	121	92	21	Wind	150.00		Domestic
2617	S. C. Foster	do	G 3	1887	Bored, 4-inch	130	119	105	23	do	110.00		do
2618	Mrs. S. Foster	do	G-3	1901	Driven, 1¼-inch	130		18	49	Hand			do
2619	A. T. Foster	do	G-3	1888	Bored, 4-inch	129		120	26	do			do
2620	S. J. Arey	Santa Gertrudis	G 3	1891	Bored, 7-inch	130	119	139	25	Wind			do
2621	Geo. Tweedy	do	H-2	1885?	Bored, 4-inch	154	140	58	29	do			Domestic; stock
2622	G. W. McCampbell	do	H-2,3	1878	do	153	138	60	28	do			Domestic
2623	A. A. Tweedy	do	H-2	1888?	Bored, 7-inch	157		73	32	do			do
2624	E. W. Reider	do	H-3	1901	Bored, 4-inch	155		90	29	do	100.00		do
2625	L. L. Bequett	do	H-2	1898	Driven, 1¼-inch	157		14	25	Hand			Stock
2626	do	do	H-2,3	1868	Bored, 4-inch	157		40	25	do			Domestic
2627	Mrs. McFarland	do	H-3	1899	do	152		80	26	Wind			do
2628	do	do	H-3	1902	Bored, 12-inch	152	135	484	30				Not used
2629	S. G. Reynolds	do	H-3	1883?	Bored, 4-inch	150		84	35	Wind			Domestic
2630	W. T. East	do	H-3	1880?	do	148		72	36	do	72.00		do
2631	Stanley & Tweedy	do	H-3	1880?	do	148	133	67	27	Hand			do
2632	A. D. Kellam	do	H-3	1902	do	150	134	78	24	do	38.00		do
2633	A. O. Kempher	do	H-3	1878?	Dug, 3 by 3 foot	149	137	13	102	do			do
2634	J. W. Cate	do	H-3	1903	Bored, 4-inch	147	134	72	35	Gas	48.00		Domestic; irrigation
2635	A. D. Kellam	do	H-3	1898	do	149	136	60	25	Wind			Domestic
2636	Mrs. E. Taylor	do	H-3	1901	Bored, 5-inch	150		55	26	do	35.00		do
2637	do	do	H-3	1885	Bored, 7-inch	148	136	150	19?				do
2638	S. K. Stamps	do	H-3	1903	Bored, 5-inch	148	136	55	40	Hand	50.00		Stock
2639	E. S. Johnston	do	H-3	1902	do	147		57	30	Wind	50.00		Domestic
2640	S. C. Roney	do	H-3	1903	do	142		51	35	do	44.80		Domestic; stock
2641	M. L. Bangle	do	H-3	1895	Driven, 1¼-inch	144		19	38	Hand			Domestic
2642	A. Keltz	do	H-3	1896	Bored, 3-inch	143		60	34	do	30.00		do
2643	do	do	H-3	1891	Driven, 1¼-inch	143		17	37	do			Stock

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
2644	E. Collins	Santa Gertrudis	H-3	1879?	Bored, 4-inch	143	133	80	26	Wind			Domestic; stock	
2645	J. P. Fleming	do	G, H-3	1887	do	142	131	73	35	do			Domestic	
2646	Wm. Caruthers	do	G-3	1898	Bored, 2-inch	141		73	32	Hand			do	
2647	do	do	G-3	1898	do	140		68	33	do			do	
2648	D. Tweedy	do	G, H-3	1895?	Bored, 4-inch	140	131	52	30	Wind			do	
2649	O. Stanley	do	G-3	1883	do	138		70	29	do			do	
2650	J. J. Tweedy	do	G-3	1888?	do	138	127	60	26	do			do	
2651	A. L. Ball	do	G-3	1885	Bored, 7-inch	131	117	675					Not used	
2652	do	do	G-3	1888	Bored, 4-inch	135		85	27	Wind			Domestic	
2653	J. P. Fleming	do	G-3	1898	Driven, 1¼-inch	135		14	48				Domestic; stock	
2654	A. W. Neighbors	do	G-4	1890?	Bored, 4-inch	132		85	27	Wind			Domestic	
2655	C. B. Miller	do	G-4	1885?	Driven, 1¼-inch	131		16	52	Hand			do	
2656	J. W. Neighbors	do	G-4	1892	do	131		17	39	do			do	
2657	H. D. Talbert	do	G-4	1892?	Bored, 4-inch	130		85	28	do			do	
2658	E. H. Henry	do	G-4	1888?	do	128	118	20	42	do			do	
2659	S. J. Williams	do	G-4	1896	Driven, 1¼-inch	130		16	62	do			do	
2660	C. Corsen	do	G-4	1870?	Bored, 4-inch	128	118	20	47	do			do	
2661	A. W. Neighbors	do	G-4		do	129	119	73	28	do			do	
2662	Mrs. A. Cole	do	G-3, 4	1887?	do	128		93	33	Wind			do	
2663	J. H. Burke	do	G-4	1875?	Bored, 7-inch	128	117	96	27	do			do	
2664	M. Bohen	do	G-4	1903	Driven, 2-inch	125		14	40	Hand			do	
2665	Frank Burke	do	G-4	1891	Bored, 4-inch	119		84	28	Wind			Domestic; stock	
2666	J. D. Ardis	do	F, G-4	1901	Bored, 5-inch	117	106	86	28	Hand	$65.00		Domestic	

2667	C. A. McKnight	do	G-4	1897	Bored, 1½-inch	117		15	34	do		do	
2668	Mr. Suggs	do	G-4	1898	Hydraulic, 2-inch	116		84	31	do	35.00	do	
2669	D. Bennett	do	G-5	1893?	Bored, 4-inch	117		93	30	Wind	70.00	do	
2670	J. Smith	do	G-4,5	1902	do	118	108	95	30	Hand		do	
2671	J. C. Rives	do	G-4	1901	Driven, 1½-inch	119		15	34	do		do	
2672	H. M. Blair	do	G-4	1899	do	120		15	33	do		do	
2673	J. C. Rives	do	G-4	1883?	Bored, 4-inch	122	112	92	30	Wind		Stock	
2674	H. G. Harper	do	G-4	1890?	do	123	113	84	34	do	75.00	Domestic	
2675	G. F. Brownson	do	G-4	1880?	do	125		84	26	Hand	75.00	do	
2676	L. McLane	do	G-4	1898	do	127		83	37	do	75.00	do	
2677	J. C. Simmons	do	G-4	1896?	do	127		90	20	Wind	80.00	Domestic; stock	
2678	Ella L. Squire	do	G-4	1898	Bored, 2-inch	130		82	34	do	34.00	Domestic	
2679	Mr. Cohen	do	G-4	1875	Bored, 4-inch	131		104	23	do		Stock	
2680	A. S. Gray	do	H-4	1880	do	139		110	29	do		Domestic	
2681	A. Rubio	do	G-4	1903	Bored, 9½-inch	130	120	110		Not installed	110.00		
2682	do	do	G-4		Bored, 4-inch	130		80	31	Wind		Domestic	
2683	Sam Frankel	do	G-4	1895	Bored, 2-inch	130		48	30	Hand		do	
2684	C. Nimmo	do	H-4		Bored, 4-inch	128	115	72	56	do		do	
2685	W. B. French	do	H-4	1901	do	131		90	49	do	68.00	do	
2686	James Brookshire	do	H-4	1890	do	130	118	71	39	Wind	55.00	do	
2687	D. Woods	do	H-4	1885?	do	130	11	75	37	Hand		do	
2688	C. C. Lower	do	H-4	1890?	do	127	115	85	34	Wind		do	
2689	James W. Rugg	do	H-4	1896	Bored, 2-inch	127		78	29	do	35.00	do	
2690	A. L. Ball	do	H-4	1886	Bored, 4-inch	126	113	72	32	do		do	
2691	J. B. Graham	do	G-4	1883?	do	127		84	31	do		do	
2693	A. Thompson	do	G-4		do	123		85	32	do		do	
2694	Mrs. A. C. Smith	do	G-4	1878	do	123	111	75	32	do		do	
2695	I. M. Cochran	do	G-4	1880?	Bored, 7-inch	123	110	98	29	do		do	
2697	John Strine	do	G-4	1903	Bored, 4-inch	121		85	32	do	73.10	do	
2698	Doctor Rowley	do	G-4,5	1873	Bored, 7-inch	120		80	30	do		do	
2699	Christian Church	do	G-5	1903	Bored, 4-inch	119		97	31	Hand	73.00	do	
2700	E. J. Easterly	do	G-5	1889?	Bored, 5-inch	118		100	31	Wind		do	
2701	Mrs. J. Harris	do	G-5	1885	Bored, 4-inch	119		88	41	do		do	
2702	Mrs. M. E. Frankel	do	G-5	1903	Bored, 5-inch	119	111	86	36	Hand	80.00	do	
2703	B. F. Witherspoon	do	G-5	1887	Bored, 4-inch	118	108	70	34	do	60.00	do	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
2704	W. H. Steel	Santa Gertrudis	G-5	1903	Bored, 4-inch	118	108	90	30	Hand	$76.50		Domestic	
2705	Mrs. E. F. Scribner	do	G-5	1893	do	118	108	68	33	do	55.00		do	
2706	H. A. Adams	do	G-5	1902	Bored, 5-inch	118	109	83	32	do	72.25		do	
2707	W. E. White	do	G-5		Bored, 7-inch	119	108	70	32	do			do	
2708	Mrs. J. M. Smith	do	G-5	1901	Bored, 4-inch	119	108	91	34	do	75.00		do	
2709	Doctor Haygood	do	G-5		do	120	109	85	32	Wind			do	
2710	S. K. Woodward	do	G-4	1885?	do	121	111	75	30	do			do	
2711	Dr. J. H. Reed	do	G-4	1898	do	122	110	84	29	do	70.00		do	
2712	S. Cohen	do	G-5	1884	do	121	110	96	29	do	65.00		do	
2713	D. P. Smart	do	G-5	1901	Bored, 5-inch	119		90	30	Gas	85.00		do	
2714	J. H. McCullough	do	G-5	1903	do	120	110	90	30	do	80.00		Domestic; irrigation.	
2715	Mrs. R. Steinart	do	G-5	1894	Bored, 4-inch	118		88	30	Wind	60.00		Domestic	
2716	D. P. Smart	do	G-5	1903	Bored, 5-inch	118	108	80	39	do	75.00		do	
2717	Geo. Elliott	do	G-5	1903	do	119	109	87	30	Hand	79.00		do	
2718	Mrs. M. E. Frankel	do	G-5	1901	do	120	110	62	33	do	65.00		do	
2719	James Booker	do	G-5	1885?	Bored, 7-inch	120	110	73	28	Wind			do	
2720	J. C. Stout	do	G-5	1903	Bored, 5-inch	121	111	87	40	do	70.00	$57.00	Domestic; stock	
2721	T. R. Crawford	do	G-5	1896?	Bored, 10-inch	119	108	86	36	Gas, wind			Domestic; irrigation.	
2722	Joe Wegerer	do	G-5	1880?	Bored, 7-inch	120	109	84	45	Wind, hand			Domestic	
2723	D. J. Marr	do	G-5		Dug, 2 by 2 foot	119	114	9	49	Hand			do	
2724	do	do	G-5	1903	Bored, 5-inch	119	110	72	40	do	65.00		Stock	
2725	Miss M. Kellar	do	G-5	1880?	Bored, 4-inch	120	108	78	33	do			Domestic	

2726	L. Saalfeldt	do	G-5	1880?	do	119	110	54	38	do		do		
2727	J. E. Jenison	do	H-5	1903	do	119	109	69	31	do	45.00	do		
2728	T. F. Renfro	do	H-5		do	118	102	55	31	do		do		
2729	J. E. Jenison	do	H-5	1899	do	118		63	31	Wind	40.00	do		
2730	do	do	H-5	1890	do	118		55	40	do	30.00	do		
2731	A. Anderson	do	H-5	1895	Hydraulic, 2-inch	117		75	41	do	35.00	do		
2732	R. T. Newcomb	do	H-5	1903	do	116		80	51	Hand	36.00	do		
2733	do	do	H-5	1870	Dug, 3 by 3 foot	116	108	13	56	do		Domestic; stock		
2734	J. W. Pangborn	do	H-5	1902	Bored, 5-inch	113	106	52	48	do	44.00	do		
2735	Chas. Harding	do	H 5	1903	do	112	105	55	43	do	58.00	Domestic		
2736	Mrs. Clearwater	do	H 5,6	1902?	do	111	102	68	49	do	63.00	do		
2737	C. C. Francis	do	H 5	1894?	Bored, 4-inch	111		60	56	Wind		Domestic; stock		
2738	John W Rudd	do	H 5	1900	do	115		56	28	do	43.00	do		
2739	J. W. Ragland	do	H-5	1888	Dug, 3 by 3 foot	119	108	16	61	Hand		do		
2740	H. M. Conch	do	H-5	1903	Bored, 5-inch	120	110	58	107	do	53.00	Domestic		
2741	Roy Jenison	do	H-5	1897	Bored, 2-inch	125		65	52	Wind		do		
2742	J. E. Jenison	do	H-5	1873	Bored, 7-inch	125	115	380	28	do		do		
2743	E. J. Standlee	do	H-5	1870?	do	128	114	71	44	do		Stock		
2744	do	do	H-4	1900	Bored, 4-inch	129		66	39	do	60.00	Domestic		
2745	Frank Morrison	do	I-4,5	1897	do	126	115	55	53	Hand	30.00	do		
2746	R. W. Wright	do	I-4,5	1899	do	123	110	46	30	do	32.00	do		
2747	H. S. Redfield	do	I-4	1901	do	127		58	44	Wind	50.00	40.00	Domestic; stock	
2748	Wm. Campbell	do	H, I-4	1903	Bored, 5-inch	131		68	51	Hand	62.50	Domestic		
2749	W Morrison	do	H-4,5		Bored, 4-inch	128		65	45	do		do		
2750	J. M. Mayes	do	H-4	1898	do	131		68	57	Wind	45.00	do		
2751	W. D. Mansfield	do	H-4	1893	Bored, 2-inch	132		58	46	Hand	35.00	do		
2752	S. A. Wilks	do	H-4	1898	Bored, 4-inch	133	122	56	53	do		do		
2753	J. Edmondson	do	H-4	1891?	Bored, 7-inch	131	101	140	24	Wind		do		
2754	J. A. Smith	do	H-4	1903	Bored, 4-inch	130	120	70	56	Hand	60.00	do		
2755	John Bartlett	do	H-4	1891?	do	130		72	42	do	50.00	do		
2756	R. S. Mayes	do	H-4	1880?	do	131	120	70	37	Wind	46.00	Domestic; stock		
2757	Wm. Sex	do	H-4	1891	Driven, 1¼-inch	132		12		Hand		do		
2758	H. Griffith	do	H-4	1890	Bored, 4-inch	134		76	31	Wind	65.00	Domestic		
2759	do	do	H-4	1903	Bored, 5-inch	134	123	60	34	do	75.00	Domestic; stock		
2760	do	do	H-4	1903	Bored, 12-inch	137	126	180		Gas		Irrigation		†100

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
2761	Mr. Carruthers	Santa Gertrudis	H-4	1885?	Bored, 4-inch	137	126	83	30	Hand			Domestic	
2762	Gallioin School	do	H-4	1895	do	138		80	28	do			do	
2763	J. E. Walton	do	H-4	1891?	do	138	126	52	26	do			do	
2764	E. F. Trabant	do	H-4	1890?	do	142	126	89	42	do			do	
2765	Mrs. A. Hagan	do	H-3,4	1892?	do	143		62	35	Wind			do	
2766	Mr. Stephenson	do	H-4		do	140		80	40	Hand			do	
2767	Wm. Morrow	do	H-4	1895	do	138		78	49	do			do	
2768	John Nelson	do	H-4	1897	do	139	127	64	37	Wind	$40.00		do	
2769	Wm. Sex	do	H-4	1895	do	137		100		do	70.00		do	
2770	C. W. Nelson	do	H 4	1895	Dug, 4 by 4 foot	138	126	15	68	do			Domestic; stock	
2771	Walter Grace	do	H 4	1901	Bored, 4-inch	137		70	69	do	29.00+	$40.00	Domestic	
2772	D. F. Conant	do	I-4		do	133		78	42	do			do	
2773	H. W. Kenney	do	I-4	1887?	Bored, 2-inch	132		80	38	Hand			do	
2774	R. S. Davis	do	I-4	1900	Bored, 4-inch	129		68	33	Wind	51.00	35.00	do	
2775	W. M. Ramp	do	I 4	1887	do	130		56	27	do	35.00		do	
2776	Mrs. M. Van Deusen	do	I-4	1885?	do	132	124	49	53	Hand	40.00		do	
2777	T. Van Deusen	do	I-4	1901	do	133		50	56	Gas, wind	42.00	155.00	Domestic; irrigation.	
2778	J. S. Williams	do	I-4	1884?	do	134		58	32	Wind			Domestic	
2779	Peter Ralph	do	I-4	1893	Driven, 1¼-inch	135		26	59	Hand			do	
2780	P. R. Ralph	do	I-4	1890?	Bored, 4-inch	136		58	34	do	35.00		do	
2781	H. H. Mills	do	I-4	1898?	do	138		58	42	Wind			Domestic; stock	
2782	L. R. Paxton	do	I-4	1901	do	140		63	24	do	50.00	35.00	Stock	
2783	H. E. Jamieson	do	I-4	1865?	Bored, 7-inch	141		31	35	Hand			Domestic	

2784	Mr. Crawford	do	I-4	1900	Hydraulic, 2-inch.	140		65	30	do	35.00		do
2785	G. S. Beckwith	do	I-4	1895	Dug, 4 by 4 foot	140	124	18	77	do			do
2786	J. J. King	do	I-4	1888?	Bored, 4-inch	141		62	30	Wind			do
2787	C. Vulgamott	do	I-4	1889?	Bored, 7-inch	142		65	29	do			do
2788	James Stewart	do	I-3,4	1888	Bored, 4-inch	142	126	70	34	do	55.00		Domestic; stock.
2789	Wedemeyer estate	do	I-4	1896?	Hydraulic, 2-inch.	138		53	35	Hand?	40.00		Stock; domestic.
2790	E. R. Wylie	do	I-4	1888?	Bored, 4-inch	144		69	34	Wind	52.00		Domestic
2791	E. Clay	do	H, I-3	1890?	do	145	136	49	31	Hand			do
2792	do	do	I-3		Dug, 3 by 3 foot	146	137	10	46	do			do
2793	D. Standlee	do	H-3	1903	Bored, 5-inch	146	136	70	34	Wind	60.00		do
2794	O. Burke	do	I-3	1889?	Bored, 7-inch	145		80	33	do	100.00		do
2795	Dr. J. Allen Osmun	do	I-3	1903	Bored, 5-inch	150	135	62		Gas, wind	55.80	250.00	Domestic; stock.
2796	do	do	I-3	1903	Bored, 4-inch	155		64	28	Wind, gas	60.00		do
2797	E. H. Root	do	I-3	1903	Bored, 5-inch	155		62	25	Hand	46.00		Domestic
2798	H. Sarrasin	do	I-3	1890	Bored, 4-inch	151	136	69	31	Wind	55.00		Domestic; stock.
2799	S. B. Root	do	I-3	1901	do	152	136	63	41	do	47.50	35.00	Domestic
2800	J. A. Shade	do	I-3	1898	Bored, 7-inch	152		78	33	do			do
2801	Mr. Wood	do	I-3	1900	Bored, 5-inch	152	137	56	33	do	50.00		do
2802	J. G. B. Haynes	do	I-3	1891	Bored, 4-inch	148	136	56	34	Hand	75.00		do
2803	do	do	I-3	1897	Bored, 7-inch	147	136	40	31	do	65.00		do
2804	F. E. Welsh	do	I-3	1895	Bored, 2-inch	145		40	24	Wind	22.00	35.00	do
2805	W. H. Davis	do	I-3	1901	Bored, 4-inch	146		60	36	do			do
2806	John Carden	do	I-3		do	143	130	41	33	Hand			do
2807	Miss H. Clark	do	I-3	1889?	Bored, 7-inch	144	129	34	36	do			do
2808	C. Leopold	do	I-3	1898	Bored, 4-inch	141		30	39	Wind			do
2809	E. & J. Cockrell	do	I-3,4	1897	do	139		40	34	do			do
2810	W. Gould	do	I-3	1882?	do	141	119	50	22	Hand, wind			do
2811	F. C. Harvey	do	I-4	1890?	do	139	122	54	34	Wind	40.00		do
2812	J. H. Burke	do	I-3	1897	do	155		74	32	do	55.00		do
2813	do	do	I-3	1884	Bored, 7-inch	155		84	32	do	110.00		do
2814	R. H. Reynolds	do	I-3	1901	Driven, 1¼-inch	157		18	57	do			Domestic; stock.
2815	H. L. Montgomery	do	I-3	1892?	Bored, 4-inch	157	144	57	45	do	38.00		Domestic
2816	A. A. White	do	I-3	1893	do	157		70	40	do	45.00		do
2817	Rivera School	do	I-3	1895	do	160	145	45	23	Hand			do
2819	J. A. Garrison	do	I-3	1889	do	159	146	70	33	Wind	45.00		do

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
2819	J. A. Garrison	Santa Gertrudis	I-3	1899	Bored, 2-inch	159	.....	38	53	Wind	$20.00	$37.00	Domestic	.....
2820	D. H. Montgomery	do	I-3	1890?	Bored, 4-inch	159	146	65	37	Hand	40.00	.....	do	.....
2821	H. S. Welsh	do	I-3	1902	do	159	146	67	37	do	56.00	.....	do	.....
2822	H. H. West	do	I-3	1899?	do	160	146	60	37	Wind	.....	.....	do	.....
2823	Mrs. Sidwell	do	I-3	1900	do	160	.....	68	33	do	52.00	.....	do	.....
2824	S. B. Guthrie	do	I-3	1901	do	161	.....	62	32	do	52.00	.....	do	.....
2825	S. W. Burke	do	I-3	1888?	do	160	.....	64	31	Hand	48.00	.....	do	.....
2826	J. L. Groton	do	I-3	1899	do	160	147	58	32	do	48.00	.....	do	.....
2827	Pallett & Graham	do	I-3	1903	do	161	148	63	42	Wind	48.00	.....	Domestic; stock	.....
2828	F. Garrison	do	I-3	1887?	Driven, 1¼-inch	160	.....	19	51	do	8.00	.....	Domestic	.....
2829	E. F. Bryant	do	I-2,3	1899?	Bored, 4-inch	160	149	42	....	Hand	48.00	.....	Domestic; stock	.....
2830	M. S. Smith	do	I-3	1901	do	162	.....	63	37	do	50.00	.....	Domestic	.....
2831	F. M. Odell	do	I-2	1903	do	163	151	63	35	do	46.00	.....	do	.....
2832	C. B. Bullock	do	I-3	1899?	do	157	.....	80	31	Wind	60.00	.....	do	.....
2833	O. P. Passon	do	I-3	1888?	Bored, 7-inch	156	142	77	....	do	100.00	.....	do	.....
2834	Geo. Bullock	Paso de Bartolo	I-3	1902	Bored, 5-inch	157	.....	57	32	do	60.00	.....	do	.....
2835	J. A. Perkins	do	I-2,3	1899	Bored, 4-inch	159	145	70	35	do	55.00	.....	do	.....
2836	T. B. Chapman	do	I-2	1892?	Bored, 7-inch	161	148	71	31	do	95.00	.....	do	.....
2837	T. R. Passons	do	I-2	1888	Bored, 4-inch	162	.....	87	33	do	68.00	.....	do	.....
2838	H. M. Moss	do	I-2	1896?	do	164	.....	68	33	do	.....	.....	do	.....
2839	B. P. Passons	do	I-2	1903	do	163	153	57	39	do	43.00	35.00	do	.....
2840	C. S. Gilman	do	I-2	1902	Driven, 1¼-inch	162	.....	18	29	do	7.00	35.00	do	.....
2841	G. W. Scott	do	I-2	1890	do	161	.....	18	47	do	.....	.....	do	.....

2842	W. L. Borden	do	I-2	1899	do	163		16	25	do		30.00	do	
2843	V. H. Furnier	do	I-2	1900	do	166		20	22	Hand			do	
2844	McDonald Bros	do	I-2	1893	Bored, 4-inch	169	152	51	23	do	40.00		Domestic; stock	
2845	W. Hadley	do	I-2	1883?	Bored, 7-inch	168	152	22	33	do			Domestic	
2846	do	do	I-2	1899?	Driven, 1½-inch	167		16	35	do			do	
2847	H. L. Montgomery	do	I-1	1879?	Bored, 7-inch	166		49	37	Wind			Domestic; stock	
2848	W. Hadley	do	I-2	1899	Driven, 1½-inch	165		17	30	Hand			Domestic	
2849	H. White	do	I-2	1900	do	171		19	44	do			do	
2850	H. S. White	do	I-2	1900	Bored, 4-inch	171	156	40	26	Wind	30.00		do	
2851	T. L. Gooch	do	I-2	1903	do	171		48	29	Hand	42.00		do	
2852	Henry White	do	I-2	1886	do	173		30	26	do	30.00		do	
2853	E. C. Coffman	do	I-1	1898	Hydraulic, 2-inch	173		30		Gas?	21.00		do	
2854	B. C. Coffman	do	I-1	1885?	Bored, 4-inch	173	154	40	31	Wind			Domestic; stock	
2855	J. J. Nagle	do	I-1	1890?	do	176	158	63	30	do	50.00		Domestic	
2856	J. Carden	do	J-1		Bored, 1½-inch	180		20	38	do			do	
2857	W. L. Witherow	do	J-1	1879?	do	181		20	33	do			Domestic; stock	
2858	J. Barlow	do	I-1	1882	Bored, 7-inch	179	161	48	29	do			Domestic	
2859	W. L. Sidwell	do	J-1	1896	Bored, 4-inch	180	162	40	28	do	35.00		do	
2860	J. L. Hooper	do	J-1	1902	do	185	167	60	26	do	45.00		do	
2861	J. P. McGill	do	J-1	1897	Hydraulic, 2-inch	185		48	29	do	30.00		do	
2862	Mr. Everett	do	J-1		Dug, 2 by 3 foot	188	173	16	41	Hand			Stock	
2863	F. A. Coffman	do		1898	Hydraulic, 2-inch	188		29	24	Wind	21.00		Domestic	
2864	Fred Layman	do	J-1	1902	Bored, 5-inch	188		52	24	do	48.00		do	
2865	John M. Chassee	do	J-1	1895	Dug, 2 by 3 foot	190	175	16	35	Hand			do	
2866	John T. Jones	do	J-1	1896?	Bored, 4-inch	186	169	34	36	do			do	
2867	E. Gurada	do	J-1		Bored, 7-inch	180	170	41	26	Wind			do	
2868	Ranchito School	do	J-1	1876	Bored, 4-inch	182		50	29	do	30.00		do	
2869	Albert Duffill	do	J-1	1893	Bored, 7-inch	179	160	84	28	do			Domestic; stock	
2870	B. M. Hotchkiss	do	J-1	1890	Bored, 4-inch	180	163	87	31	do			Domestic	
2871	J. L. Spencer	do	J-1	1900	do	179		45	33	do	35.00		do	
2872	P. A. McGaugh	do	J-1	1901	do	178	161	35	31	do	30.00		do	
2873	J. Dunlap	do	J-1	1879?	Bored, 7-inch	172	156	50	33	do			do	
2874	P. G. McGaugh	do	J-1	1890	Bored, 4-inch	174	157	35	40	Hand	30.00		do	
2875	Theodore Johnson	do	J-1	1888	do	174	157	45	32	do			do	
2876	do	do	J-1	1890?	do	174	157	45	31	do			Stock	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
2877	Tracy Abbott	Paso de Bartolo	J-1,2	1892?	Bored, 4-inch	172		50	29	Wind			Domestic	
2878	W. P. Story	do	J-2	1893	do	172		49	37	do	$37.00		do	
2879	T. E. Newlin	do	J-2		do	174	158	487	31	do			do	
2880	T. L. Gooch	do	I-2	1878	Bored, 7-inch	172	156	48	40	do	52.00		do	
2881	Mrs. A. Lynch	do	I,J-2	1887	do	169		58	33	do	58.00		Domestic; stock	
2882	R. Stroud	do	J-2	1903	Bored, 5-inch	165		51	31	do	43.50		Domestic	
2883	J. A. Montgomery	do	I-2	1898	Bored, 4-inch	168		60	30	do	46.00		do	
2884	T. L. Gooch	do	I 2	1896	do	167	153	62		do	55.00		Stock	
2885	T. P. McLane	do	I-2	1903	Bored, 5-inch	166		61	39	Hand	57.70		Domestic	
2886	J. O. Castell	Santa Gertrudis	I 3	1902	Dug, 3 by 3 foot	144	137	9	32	do			do	
2887	Frank Bonchard	do	J-3	1902	Bored, 4-inch	159	144	70	32	Wind	52.00		Domestic; stock	
2888	C. J. Gish	Paso de Bartolo	J-3	1901	Bored, 5-inch	157	147	44	35	Hand	39.00		Domestic	
2889	do	do	J-3	1901	do	158	147	89	33	do	35.00		Stock	
2890	F. Bonchard	do	J 3	1897?	Bored, 2-inch	158		68	31	Wind	38.50		Domestic	
2891	John Seppi	do	J-3	1903	Bored, 5-inch	159	146	58	34	do	52.00		do	
2892	J. A. Cover	do	J 3	1896	Bored, 2-inch	155		63	29	Hand	31.00		do	
2893	M. J. Brooks	do	J-3	1896	do	154		60	32	Wind	26.00	$45.00	do	
2894	H. Miller	do	J-3	1900	Bored, 4-inch	151	143	51		Hand			do	
2895	Aaron Miller	do	J-3	1901	Bored, 7-inch	153	142	60	33	Wind			Domestic; stock	
2896	M. L. Kendal	do	J-3	1895	Bored, 5-inch	151	141	60	32	Hand	48.00		do	
2897	T. F. Stuckle	do	J-3	1896	Bored, 4-inch	180		78	33	do	49.50		do	
2898	E. Poyorane	do	J-3	1895	Bored, 2-inch	180		30	32	do			Domestic	
2899	J. M. McInnis	do	J-3	1892?	Bored, 4-inch	151	141	25	46	do			do	

2900	W. C. Moore	do	J-3	1903	Bored, 2-inch	172		65	40	Wind	37.00		do		
2901	A. P. Ramirez	do	J-2	1897	Dug, 3 by 3 foot	155	148	9	45	do			do		
2902	Mrs. M. Theland	do	J-2	1894?	Bored, 4-inch	157	146	72	39	do					
2903	L. I. Lane	do	J-2	1902	do	150		105	33	do			Domestic		
2904	James Graham	do	J-2	1895	Bored, 2-inch	161		60	33	do			Domestic; stock		
2905	do	do	J-2	1896?	Bored, 7-inch	162	151	31	37	Hand			Stock		
2906	John T. Jones	do	J-2	1896?	Bored, 4-inch	164	154	88	35	do			Domestic; stock		
2907	Mrs. M. Pleland	do	J-2	1876	Bored, 7-inch	167	156	42	35	Wind			do		
2908	I. O. Rogers	do	J-2	1899	Bored, 2-inch	167		55	34	do			Domestic		
2909	I. T. Isbell	do	K-2	1887	Bored, 4-inch	170		74	31	do			Domestic; stock		
2910	do	do	K-2	1903	do	176		63	36	do	53.50		do		
2911	Chas. Sanderson	do	K-2	1895?	Bored, 7-inch	174	163	49	40	Hand			Domestic		
2912	H. W. Judson	do	K-2	1899	Hydraulic, 2-inch	174		70		Gas?	35.00		do		
2913	do	do	K-2	1897	Bored, 4-inch	174		68	30	Wind	70.00	40.00	Domestic; stock		
2914	Pico School	do	K-1,2	1886?	do	177		68	28	Hand			Domestic		
2915	M. Holbrook	do	K-1	1897	do	179		65	27	Wind	55.00		Domestic; stock		
2916	Whittier Water Co	do	J, K-1	1898	Bored, 12-inch	195	178	152	27	Compressed air	380.00		Domestic		56
2917	do	do	J, K-1	1898	do	195	178	150		do	375.00		do		
2918	Dan Phelan	do	K-1	1897	Bored, 4-inch	197	182	44	35	Hand	33.00		Domestic; stock		
2919	Theodore Castillo	do	K-1	1899	Dug, 3 by 3 foot	200	179	23	30	do			Domestic		
2920	H. W. R. Strong	do	K-1	1870?	Bored, 7-inch	212	158	75	80	Wind			do		
2921	do	do	K-1	1902	Bored, 10-inch	210	166	500+					Not used		
2922	R. McNess	do	K-2	1899?	Bored, 4-inch	208	164	90	61	Wind			Domestic		
2923	Whittier State School	do	L-2	1903	Bored, 12-inch	222	168	800		do			Domestic; stock		
2924	J. Sorensen	do	K-2	1878	Bored, 7-inch	203		400			1,200.00		Not used		
2925	do	do	K-2	1898	Dug, 3 by 3 foot	202	164	46	92	Wind			Domestic		
2926	A. King	do	K-2	1887	Bored, 4-inch	171		65	72	do			Domestic; stock		
2927	J. King	do	K-3	1888	do	167	157	52	68	Hand			Stock		
2928	C. E. Archer	do	K-3	1900	Bored, 7-inch	165	156	80		Gas	80.00		Irrigation		145
2929	do	do	K-3	1900	Bored, 4-inch	163		60	63	Wind	35.00		Domestic		
2930	J. W. See	do	K-3	1898	do	165	156	51	63	Hand	48.00		do		
2931	do	do	K-3	1897?	do	160	155	25	90	do	48.00		Stock		
2932	S. V. Gregg	do	K-3	1898?	do	162	153	54	72	do			Domestic		
2933	G. W. Cole	do	K-3	1892?	Bored, 7-inch	164	153	75	98	Wind			do		
2934	B. S. Cole	Santa Gertrudis	K-3	1897	do	161	152	72	91	do			Domestic; stock		

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
2935	E. R. King	Paso de Bartolo	K 3	1890?	Bored, 4-inch	165	.....	54	57	Wind	$50.00	.....	Domestic	.....
2936	L. Terkelson	do	K 3	1901	do	162	153	49	47	Hand	.....	.....	do	.....
2937	Mrs. M. A. Nicholson	do	K 3	1902	Bored, 5-inch	162	156	75	57	do	66.00	.....	do	.....
2938	M. M. Burke	do	K 3	1903	do	166	.....	75	83	Wind	.....	.....	do	.....
2939	C. C. Smith	do	K 3	1889?	Bored, 4-inch	165	.....	75	47	do	.....	.....	do	.....
2940	E. Johnson	do	K 3	1900	do	164	156	59	42	Hand	50.00	.....	do	.....
2941	Mrs. M. J. King	do	K 3	1893?	do	161	.....	65	36	Wind	.....	.....	do	.....
2942	A. J. Nicholson	do	J, K 3	1903	do	158	149	59	42	Hand	50.00	.....	Domestic; stock	.....
2943	Mrs. M. Burghardt	do	J 3	1895	Bored, 2-inch	155	.....	65	37	do	.....	.....	Domestic	.....
2944	D. E. Poyorena	do	K 3	.....	Bored, 4-inch	155	146	19	41	do	.....	.....	do	.....
2945	P. T. Swaine	do	J, K 3	1895	Bored, 7-inch	155	143	64	40	Wind	.....	.....	do	.....
2946	A. B. Briswalter	do	K 3	1902	Bored, 4-inch	154	143	133	48	Hand	113.00	.....	do	.....
2947	J. T. King	Santa Gertrudis	K 3	1902	Bored, 6-inch	156	.....	70	59	Wind	.....	.....	Domestic; stock	.....
2948	Joe Hynes	do	K 3	1888	Bored, 4-inch	159	148	103	35	do	.....	.....	Domestic	.....
2949	Geo. Hatch	Paso de Bartolo	K 3	1890?	do	159	.....	70	37	do	.....	.....	Domestic; stock	.....
2950	John Lewis	Santa Gertrudis	J 3	1898	do	156	.....	75	40	do	.....	.....	Domestic	.....
2951	Los Nietos School	do	J, K 3	.....	Bored, 6-inch	156	.....	60	44	Hand	.....	.....	do	.....
2952	Los Nietos Packing House.	do	J-4	1897	Bored, 4-inch	160	147	48	43	do	.....	.....	Packing	.....
2953	L. Duran	do	J-4	1880?	Dug, 4 by 4 foot	160	138	25	48	do	.....	.....	Domestic	.....
2954	Mr. Girado	do	J-4	.....	Dug, 2 by 3 foot	162	137	27	41	do	.....	.....	do	.....
2955	Max Schwede	do	J 4	1901	Bored, 6-inch	160	.....	92	39	do	.....	.....	do	.....
2956	Lucy Girado	do	J 4	1901	Bored, 7-inch	159	.....	90	38	do	.....	.....	do	.....
2957	Central Oil Wells	do	K 4	1900	Bored, 4-inch	157	.....	86	33	do	.....	.....	do	.....

2958	*Murphy Oil Co*	do	K-4	1903	do	157		117	32	do			do	
2959	J. D. Rimrez	do	K-4	1901	Bored, 7-inch	161		85	29	Wind			do	
2960	D. C. Cartwright	do	K-4	1901	Bored, 6-inch	159		70	35	do			do	
2961	E. W. Pitman	do	K-4	1870	Bored, 7-inch	157	134	103	30	do			do	
2962	F. A. Sanchez	do	K-4	1900	do	159	130	36	55	do			do	
2963	do	do	K-4	1901	Bored, 10-inch	158	131	205		Compressed air	270.00	$1,700.00	Irrigation	40
2964	T. L. Sanchez	do	K-4	1898	Bored, 7-inch	158		90	58	Wind	81.00		Stock	
2965	Sophia Elisalea	do	K-4	1892	Dug, 5-foot diameter.	160	130	31	65	Hand			Domestic	
2966	Mrs. Linares	do	K-4	1877	Dug, 5 by 5 foot	157	130	28	54	do			do	
2967	do	do	K-4	1887	Dug, 4 by 4 foot	155	135	22	79	do			do	
2968	V. D. Acost	do	K-4	1888	do	152	135	19	63	do			do	
2969	G. Martinez	do	K-4	1898	Dug, 2½ by 2½ foot	145	137	11	59	do			do	
2970	Fred Valla	do	K-4	1903	Bored, 4-inch	148		70	31	do	50.00		do	
2971	do	do	L-3	1896	do	145		54	73	Wind	46.00		do	
2972	Geo. Quigley	do	L-3	1900	Dug, 2 by 4 foot	144	131	9		do			Domestic; stock	
2973	C. E. Cole	do	L-3	1899	Bored, 7-inch	146	135	107	56	do			do	
2974	B. Sharpless	do	L-3	1887?	Bored, 4-inch	149		120	47	do			Domestic	
2975	J. Cole	do	L-3		Bored, 7-inch	162		65	89	do			do	
2976	Evergreen Water Co.	do	L-3	1900	Bored, 9½-inch	187	155	150		Gas	*5,400.00		Irrigation	125
2977	do	do	L-3	1900	Bored, 12-inch	187	155	84		do			do	
2978	J. Cole	do	L-3	1894	Bored, 4-inch	177	151	60	75	Wind			Domestic	
2979	C. A. Landreth	do	L-3	1901	do	191	160	78	102	Hand	75.00		Domestic; stock	
2980	Santa Gertrudis Irrigation Co.	do	L-4	1899	Bored, 10-inch			53					Not used	
2981	do	do	L-4	1898	Bored, 7-inch	143	136	54	88	Steam			Irrigation	†60
2982	do	do	L-4		Bored, 12-inch	143	136	32		do			do	
2983	do	do	L-4	1899	Bored, 10-inch	143	136	52		do			do	
2984	do	do	L-4	1899	do	143		44					Not used	
2985	H. V. Vorce	do	L-4	1894	Hydraulic, 2-inch	144		50	81	Hand			Domestic	
2986	do	do	L-4	1897	Bored, 10-inch	146	139	32		Gas	75.00	450.00	Irrigation	20
2987	P. M. Mowry	do	L-4	1901	Driven, 1½-inch	145		18	75	Hand			Domestic	
2988	Gunn Ranch	do	L-4	1895?	Bored, 3-inch	145		40	63	do			Domestic; stock	
2989	C. L. Wheeler	do	L-4	1900	Bored, 7-inch	150	125	45	107	Gas			Irrigation	†10
2990	Jacob Chase	do	L-4	1887?	Bored, 4-inch	144	128	45	104	Wind			Domestic	
2991	W. O. Graham	do	L, M-4	1895	Driven, 1½-inch	146		28	120	Hand			do	

Wells in the Downey quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*						*Miner's inches.*
2992	John Wood	Santa Gertrudis	M-4	1898	Bored 10-inch	148	122	660	80	Hand			Stock	
2993	do	do	M-4	1904	Bored, 7-inch	150	127	46		Wind	$50.00		Domestic	
2994	Colima Tract Water Co.	do	L-4,5	1902	Bored, 10-inch	133	118	152	83	Compressed air	350.00		Irrigation	110
2995	do	do	L-4,5	1899	do	135	118	154		do	350.00		do	
2996	V. Rais	do	L-5	1887?	Bored, 4-inch	145		35	63	Wind			Domestic	
2997	T. Resndes	do	M 4,5	1898	Dug, 3 by 3 foot	146	130	19	120	Hand			Domestic; stock	
2998	J. Sanchez	do	M-4	1901	Bored, 4-inch	183	148	47	75	do			do	
2999	A. A. Gueirre	do	N 5	1900	Dug, 4 by 4 foot	209	178	33	89	do			do	
3000	M. Contreras	do	N-5	1901	Dug, 3-foot diameter.	203	181	23	93	do			Domestic	
3001	R. S. Lambert	do	N 5	1895	Dug, 3½-foot diameter.	227	192	37	61	do			do	
3002	G. W. Fulwider	do	N-4	1902	Bored, 7-inch	232	192	116	55	Wind	120.00	$55.00	Domestic; stock	
3003	Sam Mendenhall	do	N-5	1901	Bored, 10-inch	195	174	28	62	do			do	
3004	H. L. Riggins	do	N 4	1900	Bored, 6-inch	255	185	190	57	do	200.00		do	
3005	Cyrus Baldwin	do	N-4	1901	Bored, 7-inch	278	190	165	48	do			do	
3006	Chas. Scott	do	N-5	1897	Bored, 4-inch	225		140		do			Not used	
3007	E. W. Cole	do	N-5	1895?	Bored, 7-inch	222	182	90	55	do			Domestic; stock	
3008	Walter Jackson	do	N-4	1901	do	253		106	38	Hand			do	
3009	Wm. K. Green	do	M,N-4	1896	do	270	180	327			500.00		Irrigation	
3010	N. Thill	do	M-4	1901	Bored, 5-inch	175		62	120	Wind			Domestic	
3011	Mrs. Stoddard	do	M-4	1897	Bored, 4-inch	168		100	172	do			do	
3012	J. B. Willey	do	M-4	1896	do	157		86	120	do			do	

3013	Woodward & Graham	do	M-4	1901	Bored, 10-inch	173	140	85	106	Gas	300.00		Irrigation	†60
3014	T. H. Woodward	do	M-4	1900	Bored, 7-inch	173	130	65	106	Wind			Domestic	
3015	J. L. Gales	do	M-4	1892	Bored, 4-inch	188		130		Hand			Not used	
3016	E. W. Hazzard	do	M-4	1890	do	163		98	126	Wind			Domestic	
3017	W. T. Brookaw	do	L-4	1897	Bored, 7-inch	167		78	134	Hand			do	
3018	Geo. L. Hazzard	do	L,M-3	1895	do	215		165		Wind			Not used	
3019	H. C. Baldwin	do	M-3	1892?	do	280	155	154		do				
3020	J. B. Willey	do	L,M-5	1888?	do	127	127	170	91	Artesian				2
3021	C. M. Mayer	do	N-4	1903	do	265	173	163	32	Gas		150.00	Irrigation	†1

Wells in Las Bolsas quadrangle.

[* Cost of well and equipment combined; † yield estimated or statement of owner taken; ? doubtful.]

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°F.					*Miner's inches.*
1	M. J. Edwards	La Bolsa Chica	M-1	1874	Bored, 7-inch	19	19	116	25	64	Artesian			Irrigation	29
2	Chico district school	do	M-1	1894	Bored, 2-inch	21	21	300	27	64	do			Domestic	4
3	W. J. Edwards	do	M-1	1896	do	20	20	125	26	64	do	$50.00		Irrigation; domestic.	4
4	do	do	M-2	1899	Bored, 3-inch	20	20	128	25	65	do	60.00		Irrigation	8
5	do	do	M-2	1898	Bored, 3½-inch	19	19	130	26	64	do			do	10
6	do	do	M-2	1899	Bored, 2-inch	19	19	114	26	64	do	45.00		do	†5
7	do	do	M-2	1899	do	18	18	165	26	64	do	65.00		do	4
8	do	do	N-2	1901	Bored, 4-inch	19	19	64	25	64	do	35.00		do	4
9	do	do	M-2	1900	do	19	19	170			do			do	†3
10	do	do	M-2	1896	Bored, 2-inch	19	19	72			do	30.00		do	†4

Wells in Las Bolsas quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
11	W. J. Edwards	La Bolsa Chica	N-2	1898	Bored, 3½-inch	19	19	74	26	65	Artesian	$30.00		Irrigation	3
12	....do	....do	N-2	1898	....do	19	19	75			....do			....do	†4
13	....do	....do	M-2	1898	....do	19	19	75	30	64	....do			Not used	
14	....do	....do	M-1	1898	....do	20	20	194	27	65	....do			Irrigation; stock	10
15	....do	....do	M-2	1897	Bored, 7-inch	20	20	160	26	65	....do			Irrigation	1
16	....do	....do	N-1	1898	Bored, 2-inch	20	20	119			....do	45.00		....do	†2
17	....do	....do	M-2	1899	Bored, 3-inch	18	18	120	26	65	....do	65.00		....do	†3
18	Samson Edwards	....do	M-1	1900	Bored, 2-inch	19	19	135	26	64	....do	50.00		....do	†4
19	....do	....do	M-2	1900	Bored, 3-inch	19	19	135	26	64	....do			....do	10
20	....do	....do	M-1	1898	Bored, 3½-inch	19	19	135	27	64	....do			....do	8
21	....do	....do	M-2	1902	Bored, 6-inch	16	16	230			....do			....do	†26
22	Frank Bohannan	....do	M-2	1901	Bored, 2-inch	16	16	100	25	64	....do	40.00		....do	4
23	....do	....do	M-2	1902	Bored, 4-inch	15	15	214			....do	100.00		....do	4
24	W. J. Edwards	....do	M-2	1901	....do	15	15	100	27	64	....do	35.00		....do	4
25	....do	....do	M-2		Bored, 3½-inch	15	15				....do			....do	4
27	W. H. Johnson	....do	M-2		Bored, 2-inch	21	21	127	25	64	....do			....do	2
28	....do	....do	M-2		....do	15	15	130		65	....do			....do	2
28a	....do	....do	M-2		Bored, 7-inch	15	15	238	25	68	....do			....do	3
29	....do	....do	M-2		Bored, 2-inch	15	15	77			....do			....do	6
30	....do	....do	M-2		Bored, 4-inch	15	15	160	26	65	....do			....do	
31	Sampson Edwards	....do	M-2	1904	....do	15	15	68	27	64	....do			....do	17
32	....do	....do	M-2	1900	....do	15	15	70			....do			....do	14
33	....do	....do	M-3	1898	Bored, 2-inch	14	14	69			....do			....do	4

34	....do	....do	M-3	1900	Bored, 4-inch	14	14	68			....do		....do		13
35	John Edwards	....do	M-2		....do	15	15		25	65	....do		....do		
36	....do	....do	M-2		Bored, 8-inch	15	15	53	25	65	....do		....do		3
37	....do	....do	M-2	1898	Bored, 3½-inch	15	15	115			....do		Not used		
38	Wm. Kasemann	....do	M 2	1903	Bored, 3-inch	15	15	146			....do		....do		†10
39	Samuel King	....do	M 2	1904	Bored, 4-inch	16	16	73			....do		Irrigation		20
40	....do	....do	M-2	1899	....do	16	16	200			....do		....do		8
41	....do	....do	M-2	1897	....do	16	16	165?	27	64	....do		Domestic; irrigation.		21
42	....do	....do	M-2	1897	....do	16	16	165			....do		Irrigation		18
43	W. W. Barton	....do	M 2	1903	....do	16	16	160	26	64	....do		....do		15
44	....do	....do	M, N 2	1896	Driven, 4-inch	17	17	200	27	64	....do				
45	....do	....do	N 2	1903	Bored, 4-inch	17	17	82			....do		Irrigation		†28
46	....do	....do	N 2	1897	Bored, 2-inch	17	17	184	27	65	....do		....do		5
47	....do	....do	N 2	1903	Bored, 4-inch	17	17	192			....do		....do		†15
48	....do	....do	M 2	1901	....do	17	17	184	26	65	....do		....do		†14
49	....do	....do	N-2	1899	....do	17	17	220		65	....do				†14
50	G. W. More	....do	N-2	1898	....do	17	17	78	26	64	....do				5
51	....do	....do	N-2	1899	....do	18	18	80			....do				5
52	....do	....do	N-2	1898	....do	17	17	80	27	64	....do				14
53	....do	....do	N-2	1900	Bored, 7-inch	16	16	82			....do		Irrigation		7
54	....do	....do	N 2	1900	....do	16	16	86			....do				19
55	Geo. Johnson	....do	N-2		Bored, 3-inch	15	15	90	26		....do		Irrigation		12
56	B. R. Gerhart	....do	N-2	1896	Bored, 4-inch	15	15	69	25	66	....do		Domestic; irrigation.		14
57	....do	....do	N-3	1904	....do	14	14	77	28	65	....do		Irrigation		†22
58	....do	....do	N-3	1900	....do	15	15	72			....do		....do		14
59	W. E. Gerhart	....do	N-2,3		....do	15	15	98	25	64	....do		....do		
60	....do	....do	N-2,3	1899	....do	16	16	80			....do		Stock; irrigation.		8
61	....do	....do	N-3	1896	....do	17	17	80	28	64	....do		Irrigation		5
62	Dave Rogers	....do	N-2	1896	Bored, 7-inch	16	16	155			....do	120.00	Domestic; irrigation.		9
63	R. R. Gerhart	....do	N-2	1904	Bored, 4-inch	17	17	80	26	64	....do		Irrigation		†18
64	J. T. Shaffer	....do	N-2	1904	....do	17	17	72			....do		....do		†17
65	....do	....do	N-2	1898	....do	17	17	65	26	63	....do		....do		†20
66	....do	....do	N-2	1897	....do	17	17	70			....do		....do		†17

Wells in Las Bolsas quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°F.					*Miner's inches.*
67	J. T. Shaffer	La Bolsa Chica	N-2	1899	Bored, 7-inch	17	17	128			Artesian			Irrigation	†81
68	T. J. Lewis	do	N-2	1899	do	16	16	90?			do	$100.00		do	12
69	do	do	N-3	1901	do	15	15	65			do	90.00		do	†19
70	R. R. & I. J. Gerhart	do	N-3	1896	Bored, 4-inch	15	15	80	28	64	do			do	8
71	do	do	N-3	1900	Hydraulic, 3-inch.	15	15	80?			do			do	3
72	Geo. Gerhart	do	N-3	1899	Bored, 4-inch	14	14	74	26	64	do			do	14
73	do	do	M, N-3	1900	do	13	13	76			do			do	†17
74	H. H. Bentley	do	N-3	1897	Bored, 2-inch	16	16	71	25	64	do	30.00		Stock; irrigation.	†7
75	do	do	N-3	1901	Bored, 4-inch	16	16	72			do	40.00		Irrigation	†20
76	do	do	M-2, 3	1902	Bored, 2-inch	16	16	71			do	30.00		do	5
77	B. A. Farrer	do	N-3	1898	Bored, 4-inch	16	16	72	26	64	do			Domestic; irrigation.	8
78	do	do	N-3	1901	do	14	14	78			do	40.00		Irrigation	†19
79	do	do	N-3	1904	do	15	15	78			do	40.00		do	†18
80	W. T. Clark	do	M-3	1903	do	13	13	76	26	64	do			do	17
81	do	do	M-3	1898	do	13	13	74		64	do	40.00		do	10
82	do	do	M-3	1898	Bored, 7-inch	13	13	73			do	100.00		do	7
83	W. H. McGirk	do	N-3	1901	Bored, 2-inch	13	13	70	25	66	do			Domestic; irrigation.	†8
84	do	do	N-3	1900	do	12	12	68			do	30.00		Irrigation	†8
85	D. McGirk	do	N-3	1904	do	13	13	74			do	35.00		do	†9
86	do	do	N-3	1895	Bored, 4-inch	12	12	75	26	64	do			Domestic; irrigation.	17
87	D. H. Thompson	do	N-3	1901	Bored, 2-inch	14	14	72			do	35.00		Irrigation	8

88	M. C. Cole	do	N-3	1895	Bored, 3-inch	15	15	85	25	64	do	45.00		Domestic; irrigation.	12
89	F. J. Mallett	do	N-3	1897	Bored, 7-inch	17	17	120	27	65	do	90.00		do	7
90	do	do	N-3	1901	do	16	16	140			do	125.00		Irrigation	†29
91	Joseph Walton	do	N-3	1899	do	16	16	100			do			do	9
92	J. G. Blaylock	do	N-3	1896	do	16	16	90	26	63	do	75.00		Domestic	
93	J. M. Cain	do	N-3	1900	Hydraulic, 3-inch	16	16	59			do	30.00		Irrigation	10
94	do	do	N-3		Hydraulic, 2-inch	16	16	155			Wind	75.00	$40.00	Domestic; irrigation.	
95	J. L. Worthy	do	N-3	1900	Hydraulic, 3-inch	16	16	130			Artesian	75.00		do	
97	Henry Winters	do	N-3	1895	Hydraulic, 2-inch	16	16	138	28	65	do			do	
98	do	do	N-3	1896	Bored, 4-inch	16	16	138			do			Irrigation	†20
99	Jacob Walton	do	N-3	1896	Bored, 7-inch	17	17	136			do			do	†29
100	W. S. Burdick	do	N-2	1896	do	18	18	85?	27	63	do	75.00		Domestic; irrigation.	7
101	do	do	N-2	1899	Bored, 3-inch	18	18	90?	27	64	do	45.00		Irrigation	†8
102	D. Rogers	do	N-2	1898	Bored, 2-inch	18	18	85			do	35.00		Domestic; irrigation.	4
103	do	do	N-2	1900	Bored, 7-inch	18	18	84			do			Irrigation	2
104	do	do	N-2	1899	Bored, 2-inch	17	17	85			do	40.00		do	4
105	A. J. Crane	do	N-2	1895	Bored, 7-inch	17	17	79	25	64	do			Domestic; irrigation.	7
106	do	do	N-2	1900	do	17	17	175	25	64	do	250.00		Irrigation	7
107	Golden West Celery and Produce Co.	do	N-2	1903	Bored, 4-inch	17	17	198	23	64	do			Domestic; irrigation.	16
108	do	do	N-2	1894	Bored 7-inch	18	18	100	27	64	do			Irrigation	24
109	do	do	N-2	1893	do	18	18	90			do	100.00		do	1
111	do	do	N-2	1901	Bored, 3-inch	17	17	98	27	64	do	65.00		do	8
112	do	do	N-2	1901	Bored, 7-inch	17	17	98			do			do	7
113	do	do	N-2	1901	Bored, 2-inch	17	17	120			do	60.00		do	4
114	do	do	N-2	1896	Bored, 7-inch	17	17	188	26	65	do			do	2
115	do	do	N-2	1892	do	17	17	97			do			do	†7
116	do	do	N-2	1901	Bored, 3-inch	17	17	120			do			do	10
117	do	do	N-3	1901	do	17	17	110			do			do	9
118	do	do	N-2	1894	Bored, 4-inch	17	17	110	26	64	do			do	8
119	do	do	N-3	1894	Hydraulic, 4-inch	17	17	108			do			do	8
120	do	do	N-3	1898	Bored, 4-inch	17	17	140			do			do	15

Wells in Las Bolsas quadrangle—Continued.

Number of well.	Owner.	Location.	Map location	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°*F.*					*Miner's inches.*
123	B. B. Townsend	La Bolsa Chica	N-2	1903	Bored, 4-inch	17	17	260	25	66	Artesian	$200.00		Irrigation	†20
124	do	do	N-2		Bored, 7-inch	17	17	160			do			do	†24
125	J. O. Slaback	do	N-2	1901	Bored 4-inch	17	17	68	27	64	do	40.00		do	†21
126	Wm. Kasemann	do	N-2	1900	Bored, 7-inch	18	18	367	24	64	do	400.00		Domestic; irrigation; stock.	8
127	do	do	N-2	1901	Bored 3-inch	19	19	196			do	120.00		Irrigation	10
128	do	do	N-2	1903	Bored, 3½-inch	18	18	194	28	64	do			do	8
129	T. J. Lewis	do	N-2		Bored, 7-inch	18	18	86	29	64	do			Domestic; irrigation.	†7
130	do	do	N-2	1904	Bored, 4½-inch	18	18	193	29	64	do			Irrigation	5
131	Mr. Hazeltine	do	N-2	1901	Bored 2-inch	19	19	128	27	65	do	60.00		Domestic; stock	4
132	do	do	N-2		Bored, 3-inch, inside of 7-inch.	19	19	324	27	64	do			Irrigation	2
133	W. T. Clark	do	N-2	1900	Bored, 2-inch	20	20	209			do	60.00		Domestic; irrigation; stock.	5
134	do	do	N-2	1904	Hydraulic, 4-inch.	17	17	232	32	64	do			Irrigation	18
135	do	do	N-1	1896	Bored, 7-inch	18	18	75			do	45.00		do	10
136	do	do	N-1	1897	do	18	18	75	30	64	do			do	2
137	do	do	N-2	1880	do	19	19	80	29	64	do	55.00		Irrigation; domestic.	4
138	do	do	N-1	1896	do	22	22	82			do	55.70		Irrigation	4
139	W. H. Edwards	do	N-1		do	22	22	120	33	64	do			do	24
140	do	do	N-1		do	20	20	104	29	64	do			do	12
141	do	Las Bolsas	N-1		Bored, 2-inch	20	20	97	30	64	do			do	6

142	R. E. Larter	do	N-1	1874	Bored, 7-inch	25	25	102	....	64	do		Domestic; irrigation.	....	
143	do	do	N-1	1904	Hydraulic, 3-inch.	25	25	357	28	64	do		Irrigation	12	
144	Mr. Wayman	do	N-1	....	Bored, 2-inch	22	22	80	33	64	do		Irrigation; stock	....	
145	R. E. Larter	do	N-1	....	Bored, 7-inch	22	22	295	27	64	do		Irrigation	9	
146	H. F. Penhall	do	N 1	1904	Hydraulic, 3-inch.	23	23	315	28	64	do	200.00	do	11	
147	do	do	N 1	1884	Bored, 7-inch	23	23	80	....	....	do		do	Small.	
148	do	do	N-1	1902	Hydraulic, 2-inch.	24	24	327	....	....	do		do	4	
149	Mrs. M. J. Larter	do	M, N 1	....	Bored, 7-inch	22	22	72	30	64	do		Irrigation; stock.	†6	
150	E. M. Keller	La Bolsa Chica	M 1	....	do	20	20	141	26	64	do		Domestic; irrigation.	4	
151	do	do	M 1	....	Bored, 2-inch	19	19	100	26	64	do		Irrigation	Small.	
152	do	do	M-1	....	do	19	19	123	25	64	do		do	4	
153	Mrs. H. Rogers	do	M-1	1900	Bored, 3-inch	17	17	232	26	66	do		Domestic; stock..	10	
154	do	do	M-1	1876	Bored, 7-inch	17	17	87	....	....	do		Domestic	Small.	
155	J. Peters	do	L 1	....	do	17	17	89	26	65	do		Domestic; stock..	Small.	
156	Frank Wakeham	do	L 1	....	Bored, 3-inch	20	20	210	23	66	do		Irrigation	6	
157	J. H. Edwards	Las Bolsas	N 1	....	do	22	22	90	30	64	do		Not used	10	
158	do	do	N 1	1899	Bored, 7-inch	22	22	137	....	64	do		Irrigation	9	
159	do	do	N-1	1899	Bored, 3-inch	21	21	117	29	64	do		do	10	
160	Mr. Keifhaber	do	N-1	1877	Bored, 7-inch	22	22	100	29	64	do		Irrigation; stock.	12	
163	A. B. Bohnham	do	N-1	1876?	do	27	27	48	36	64	do		Domestic; stock..	Small.	
164	C. N. Hickox	La Bolsa Chica	L-2	1902	Bored, 4-inch	20	20	136	27	63	do		Domestic; irrigation.	†14	
165	Chas. Waters	do	L-2	1903	Bored, 2-inch	20	20	90	....	63	do		Irrigation	....	
166	do	do	L-2	1903	Hydraulic, 2-inch.	20	20	51	....	....	do		Irrigation; stock.	2	
167	do	do	L-2	1901	Bored, 4-inch	17	17	110	25	65	do		Irrigation	....	
168	A. D. Cleaver	do	L-2	1901	do	17	17	144	25	66	do		do	2	
169	J. J. Graham	do	M-3	1901	Bored, 7-inch	30	30	302	25	70	do		Domestic; irrigation.	2	
170	do	do	M-3	1901	do	30	30	274	....	....	do		Irrigation; stock.	2	
171	W. Shamrack	do	M-3	1903	Bored, 2-inch	16	16	55	27	....	do		Irrigation	6	
172	do	do	M-3	1903	do	16	16	58	....	....	do		do	6	
173	Ed. More	do	M-3	1899?	Bored, 4-inch	17	17	70	....	....	do		do	4	
174	do	do	M-3	1904	Bored, 3½-inch	25	25	70	24	64	do		do	12	
175	do	do	M-3	1904	do	17	17	281	24	69	do		do	15	

Wells in Las Bolsas quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°F.					*Miner's inches.*
176	A. D. Cleaver	La Bolsa Chica	M 3	1901	Bored, 3-inch	17	17	84	24	64	Artesian			Irrigation	10
177	Wm. Metzger	do	M 3		Bored, 2-inch	16	16	100	25	64	do			do	
178	do	do	M 3		Bored, 7-inch	17	17	64			do			do	4
179	Mr. Robertson	do	M 3		do	16	16		26	64	do			do	
181	W. H. Bently	do	M 3	1897	Hydraulic, 2-inch.	17	17	135			do			Stock	5
182	J. B. Robertson	do	M 3	1903	Bored, 2-inch	16	16	70	27	64	do			Irrigation	
183	J. M. Waters	do	M 3	1902	do	16	16	65			do			do	7
184	do	do	M 3	1902	do	14	14	66	26	66	do			Domestic; stock	5
185	do	do	M 3	1900	do	14	14	66			do			Irrigation	4
186	do	do	M 4	1898	Bored, 4-inch	14	14	67			do			do	†2
187	L. R. Metzger	do	M 3		do	15	15	80	25	66	do			do	†26
188	do	do	M 3		Bored, 2-inch	15	15	60			do				4
191	Wm. Shamrack	do	L 3	1898	Bored, 3-inch	20	20	70?	21		Wind			Domestic; stock	
192	do	do	L, M 3	1901	Bored, 7-inch	14	14	220	24	70	Artesian			Irrigation	7
193	John McDonald	do	M 3	1901?	Bored, 6-inch	15	15	53	22	66	do			do	36
194	Las Bolsas Land Co.	do	L 3		Hydraulic, 2-inch.	12	12	48	21	66	do			Duck pond	4
195	do	do	L 3		do	14	14	55	22	65	do			do	6
196	do	do	L 3		do	13	13	48			do			do	6
197	Geo. Travoli	do	M 3	1899	Hydraulic, 3-inch.	15	15	65	25	64	do			Irrigation	†10
198	do	do	M 3	1903	do	15	15	100?			do			do	†6
199	do	do	M 3	1899	Hydraulic, 2-inch.	15	15	70			do	$35.00		do	5
200	do	do	M 3	1902	do	15	15	73			do	35.00		Domestic; stock	4
201	do	do	M 3	1900	do	15	15	68			do	30.00		Irrigation	5

202	.....do.....	.....do.....	M-4.....	1898	Bored, 2-inch.....	15	15	66	....	....	.....do.....	.....	.....	.....do.....	†6
203	.....do.....	.....do.....	M-4.....	1898	Hydraulic, 3-inch.	15	15	70	27	64	.....do.....	40.00	.....	.....do.....	4
204	.....do.....	.....do.....	M-4.....	1903	.....do.....	15	15	66	....	....	.....do.....	38.00	.....	.....do.....	†12
205	.....do.....	.....do.....	N-4.....	1904	.....do.....	14	14	75	33	65	.....do.....	39.00	.....	.....do.....	9
206	.....do.....	.....do.....	N-3.....	1899	Hydraulic, 2-inch.	14	14	67	27	64	.....do.....	30.00	.....	.....do.....	5
207	J. B. Robertson.....	.....do.....	M-3.....	1900	Hydraulic, 4-inch.	15	15	70?	....	....	.....do.....	.....	.....	.....do.....	15
208	.....do.....	.....do.....	M-3.....	1901	Hydraulic, 2-inch.	14	14	70	....	....	.....do.....	32.00	.....	.....do.....	.....
209	T. M. Robertson.....	.....do.....	M-3.....	1903	Hydraulic, 4-inch.	15	15	85	25	64	.....do.....	54.00	.....	.....do.....	5
210	.....do.....	.....do.....	M-3.....	1901	Hydraulic, 2-inch.	14	14	70	....	....	.....do.....	.....	.....	.....do.....	†5
211	.....do.....	.....do.....	M-3.....	1902	Hydraulic, 4-inch.	15	15	70	27	65	.....do.....	45.00	.....	.....do.....	15
212	.....do.....	.....do.....	M-3.....	1902	.....do.....	15	15	70	27	65	.....do.....	45.00	.....	.....do.....	15
214	W. L. Phillipps.....	.....do.....	N-4.....	1900	Hydraulic, 2-inch.	14	14	68	27	65	.....do.....	.....	.....	.....do.....	†6
215	.....do.....	.....do.....	M-4.....	1904	.....do.....	14	14	67	....	....	.....do.....	.....	.....	.....do.....	†7
216	.....do.....	.....do.....	N-4.....	1901	.....do.....	14	14	60?	....	....	.....do.....	.....	.....	.....do.....	6
217	.....do.....	.....do.....	M-4.....	1900	.....do.....	14	14	.....	25	66	.....do.....	.....	.....	.....do.....	†6
218	D. F. Sharratt.....	.....do.....	N-3.....	1904	Bored, 2-inch.....	24	24	350	22	70	.....do.....	.....	.....	.....do.....	6
219	.....do.....	.....do.....	N-3.....	1897	Bored, 3-inch.....	23	23	148	27	64	.....do.....	.....	.....	.....do.....	5
220	Mrs. M. M. Shaffer.....	.....do.....	N-3.....	1902	Hydraulic, 3-inch.	24	24	107	26	66	.....do.....	56.00	.....	Domestic; irrigation.	4
221	.....do.....	.....do.....	N-3.....	1903	Bored, 4-inch.....	18	18	113	....	....	.....do.....	.....	.....	Irrigation.....	16
222	.....do.....	.....do.....	N-3.....	1900	.....do.....	18	18	105	....	....	.....do.....	.....	.....	.....do.....	†17
223	C. J. & S. Buck.....	.....do.....	M-4.....	1895	Bored, 3-inch.....	14	14	75?	26	65	.....do.....	.....	.....	.....do.....	9
224	.....do.....	.....do.....	M-4.....	1903	Bored, 4-inch.....	14	14	70	....	....	.....do.....	45.00	.....	.....do.....	†20
225	P. B. O'Reilley.....	.....do.....	N-3.....	1902	Bored, 2-inch.....	16	16	70	26	65	.....do.....	30.00	.....	Domestic; irrigation.	6
226	.....do.....	.....do.....	N-3.....	1902	.....do.....	17	17	70	....	....	.....do.....	.....	.....	Irrigation.....	†6
227	A. F. Lintner.....	.....do.....	N-3.....	1901	.....do.....	15	15	68	27	65	.....do.....	29.00	.....	Irrigation; domestic.	6
228	.....do.....	.....do.....	N-3.....	1903	Hydraulic, 2-inch.	17	17	84	....	....	.....do.....	40.00	.....	Irrigation.....	5
229	.....do.....	.....do.....	N-4.....	1899	Bored, 2-inch.....	15	15	65	27	64	.....do.....	30.00	.....	.....do.....	4
230	.....do.....	.....do.....	N-4.....	1898	.....do.....	15	15	68	....	....	.....do.....	30.00	.....	.....do.....	4
231	.....do.....	.....do.....	N-4.....	1899	.....do.....	15	15	65	27	64	.....do.....	30.00	.....	.....do.....	4
232	Dennis McGirk.....	.....do.....	N-4.....	1901	.....do.....	15	15	75	....	....	.....do.....	.....	.....	Irrigation; stock.	4
233	.....do.....	.....do.....	N-4.....	1902	.....do.....	14	14	76	26	65	.....do.....	33.00	.....	Irrigation.....	4
234	D. H. Thomas.....	.....do.....	N-3.....	1899	Bored, 4-inch.....	16	16	74	....	....	.....do.....	50.00	.....	.....do.....	†14
235	M. C. Cole.....	.....do.....	N-3.....	1900	Bored, 2-inch.....	15	15	.....	....	....	.....do.....	.....	.....	.....do.....	6

Wells in Las Bolsas quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°F.					*Miner's inches.*
236	M. C. Cole	La Bolsa Chica	N-3	1900	Bored, 2-inch	16	16	60			Artesian			Irrigation	6
237	do	do	N-3	1895	Bored, 7-inch	17	17	130			do			do	2
238	do	do	N-3	1895	do	19	19	131			do			do	11
239	do	do	N-3	1904	Bored, 7-inch, 184 feet; 4-inch, 125 feet.	30	30	309	25	70	do			Irrigation; domestic.	12
240	do	do	N-3		Bored, 7-inch	30	30	325			Wind			Stock	
241	Frank Lintner	do	N-3	1892	Bored, 4-inch	16	16	97	26	64	Artesian	$60.00		Domestic; irrigation.	14
242	H. S. Brakebill	do	N-3	1899	do	16	16	69	26	65	do	45.00		Irrigation	18
243	do	do	N-3	1896	Bored, 7-inch	16	16	49			do			do	4
244	John Lawrence	do	N-3	1899	Bored, 3-inch	16	16	49	25	65	do			do	Small.
245	Frank Lintner	do	N-3	1902	Bored, 2-inch	15	15	72			do	32.00		do	5
246	do	do	N-3	1899	Bored, 4-inch	16	16	97			do	60.00		do	†14
247	do	do	N-3	1897	do	16	16	68	26	64	do	45.00		do	4
248	B. F. Houser	do	N-3		Bored, 3-inch	19	19				do			do	Small.
249	do	do	N-3		Bored, 4-inch	18	18	65	27	64	do			do	1
250	S. G. Hull	do	N-4	1898	Bored, 3-inch	15	15	46			do	28.00		do	Small.
251	W. H. Hicks	do	N-4	1898	Hydraulic, 2-inch	22	22	85			Hand			Domestic; stock	
252	Huntington Beach Co.	Las Bolsas	N-5	1898	Bored, 7-inch	60	60	220	37		Wind			Stock; irrigation	
254	do	do	N-7		Bored, 10-inch	30	30	200?	35		Wind, gas			Domestic	
256	Bolsa Land Co. (gun club).	do	L-3		Bored, 2-inch	10	10	300	83	66	Artesian				Small.
257	Lometa Land Co	La Bolsa Chica	K-3		Bored, 7-inch	30	30	130	20		Wind			Domestic; stock	

258	Sunset Beach Co.	do	K 3	1901	do	18	18	184	22	68	Artesian	Not used	7	
258a	do	do	K-3	1901	do	18	18	184	22	68	do	do	5	
259	Bolsa Land Co. (gun club).	do	N 4		Bored, 2-inch	12	12	64	26	65	do	Stock; domestic	4	
260	do	do	N 4		Hydraulic, 2-inch.	12	12	58			do	Irrigation	4	
261	do	do	N 4	1901	do	14	14	42			do	do	5	
262	do	do	N 4		do	14	14	51	23	66	do	do		
263	do	do	N 4		do	14	14	52	22	66	do	Duck pond	5	
264	do	do	N 4		do	14	14		25	64	do	do	4	
265	do	do	M 4		do	12	12	52	23	66	do	do	5	
266	do	do	M-4		do	12	12	46		68	do	do	4	
267	do	do	M-4		do	12	12	68	21	64	do	do	4	
268	do	do	M 4		do	12	12	67	23	68	do	do	2	
269	do	do	M 4		do	12	12	84		66	do	do	2	
270	do	do	M-4		do	12	12	65	22	66	do	do	6	
271	do	do	M 4		Bored, 2-inch	12	12	60	25	65	do	do	7	
272	do	do	M 4		Hydraulic, 2-inch.	12	12	55	23	64	do	do	6	
273	do	do	M 4		do	12	12	65	23	64	do	do	4	
274	do	do	M 4		do	12	12	63	24	64	do	do	4	
275	do	do	M-4		Bored, 2-inch			59	23	65	do	do	6	
276	do	do	M 3		Hydraulic, 2-inch.	12	12	54	24	66	do	do	7	
277	do	do	M-3		Bored, 2-inch	12	12	54			do	do	7	
278	do	do	M-3		Hydraulic, 2-inch.	12	12	68	25	67	do	do	8	
279	do	do	M-4		do	12	12	57			do	do	6	
281	do	do	M 4		do	12	12	54	24	65	do	do	6	
282	do	do	M-3		do	12	12	43	28	68	do	do	6	
283	do	do	M-3		do	13	13	43	33	66	do	do	7	
284	J. H. Cole	do	L-3		Bored, 2-inch	14	14	55	25	68	do	Irrigation	4	
285	Lometa Land and Water Co. (gun club).	do	L-2	1903	Hydraulic, 4-inch.	15	15				do	Duck pond	8	
286	do	do	L-2	1903	do	15	15				do	do	14	
287	do	do	L-2	1903	do	15	15				do	do	4	
288	do	do	L-3	1903	do	15	15				do	do		
289	do	do	L-3	1903	do	15	15				do	do		
290	do	do	L-3	1903	Hydraulic, 2-inch.	15	15		26	66	do	do	5	
291	do	do	L-3	1903	Hydraulic, 4-inch.	15	15				do	do		

Wells in Las Bolsas quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface.	Elevation of water.	Depth of well.	Solids per 100,000.	Temperature of water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water.
						Feet.	*Feet.*	*Feet.*		°F.					*Miner's inches.*
292	Lometa Land and Water Co. (gun club).	La Bolsa Chica	L-2	1903	Hydraulic, 4-inch.	15	15	.....	.....	.....	Artesian	.....	.....	Duck pond	.....
293	.....do.....	.....do.....	L-2	1903	.....do.....	15	15	.....	26	66	.....do.....	.....	.....	.....do.....	.....
294	.....do.....	.....do.....	L-2	1903	.....do.....	15	15	.....	27	66	.....do.....	.....	.....	.....do.....	.....
295	.....do.....	.....do.....	L-2	1903	Hydraulic, 3-inch.	15	15	.....	.....	.....	.....do.....	.....	.....	.....do.....	.....
296	.....do.....	.....do.....	L-2	1903	Hydraulic, 4-inch.	15	15	.....	.....	.....	.....do.....	.....	.....	.....do.....	.....
297	F. Dimock.....	.....do.....	K-1	1898	Bored, 2-inch.....	20	20	124	26	66	.....do.....	.....	.....	Domestic; irrigation.	6
298	.....do.....	.....do.....	K-1	1902	.....do.....	22	22	152	31	.....	.....do.....	.....	.....	Irrigation.....	7
299	.....do.....	.....do.....	L-2	1903	.....do.....	22	22	190	.....	.....	.....do.....	.....	.....	.....do.....	.....
300	.....	Los Alamitos	J-1	.....	Bored, 3-inch.....	25	25	300+	19	76	.....do.....	.....	.....	Stock.....	9
301	Anaheim Beach Co.....	.....do.....	I-1	.....	Dug, 4½ by 4½ foot.	15	15	12	68	63	Hand.....	.....	.....	Domestic; stock.	.....
302	.....do.....	.....do.....	I-1	.....	Bored, 7-inch.....	15	15	100	200+	63	.....	.....	.....	Not used.....	.....

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The following papers also relate to this subject: Underground waters of Arkansas Valley in eastern Colorado, by G. K. Gilbert, in Seventeenth Annual, Pt. II; Preliminary report on artesian waters of a portion of the Dakotas, by N. H. Darton, in Seventeenth Annual, Pt. II; Water resources of Illinois, by Frank Leverett, in Seventeenth Annual, Pt. II; Water resources of Indiana and Ohio, by Frank Leverett, in Eighteenth Annual, Pt. IV; New developments in well boring and irrigation in eastern South Dakota, by N. H. Darton, in Eighteenth Annual, Pt. IV; Rock waters of Ohio, by Edward Orton, in Nineteenth Annual, Pt. IV; Artesian well prospects in the Atlantic coastal plain region, by N. H. Darton, Bulletin No. 138.

Correspondence should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

AUGUST, 1905.

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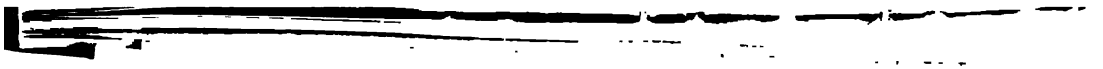

Water-Supply and Irrigation Paper No. 139 Series O, Underground Waters, 42

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

DEVELOPMENT OF UNDERGROUND WATERS

IN THE

WESTERN COASTAL PLAIN REGION OF SOUTHERN CALIFORNIA

BY

WALTER C. MENDENHALL

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

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Bill no 2177

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., January 12, 1905.

SIR: I transmit a report entitled "The Development of Underground Waters in the Western Coastal Plain Region of Southern California," prepared by Mr. W. C. Mendenhall, under the direction of Mr. N. H. Darton, and recommend that it be published as a Water-Supply and Irrigation Paper.

This paper is similar to two recently published on the eastern and central portions of the coastal plain of southern California. These papers contain a list of nearly all the wells in this section of the State, and such data as to water levels, irrigation systems, and irrigated lands as could be collected by a careful canvass. In addition each paper contains a brief discussion of the conditions affecting the underground waters in the particular section of which it treats.

The studies, a part of whose results are being made available in this way, are planned to cover all the important water-bearing lands of the valley of southern California. In most instances the facts gathered concerning the wells and the distributing systems will be supplemented by a study of the local geology, in so far as it controls the amount, distribution, and circulation of the ground waters. The hydrographic data and the geologic data will then be discussed and issued together in one report. In the coastal plain area, however, the geologic conditions being relatively simple and the hydrographic data being large in volume and of paramount importance, it is deemed best to issue the latter at once, rather than to delay it pending the working out more fully of the comparatively unimportant geologic problems. Therefore the tables and maps are presented here for the consideration of water users, with a comparatively brief text, which is chiefly descriptive, but which includes a discussion of the effects of development and drought in bringing about those changes in water levels and in the outlines of artesian areas which have been most marked within the last five or six years.

Very respectfully,

F. H. NEWELL,
Chief Engineer.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

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DEVELOPMENT OF UNDERGROUND WATERS IN THE WESTERN COASTAL PLAIN REGION OF SOUTHERN CALIFORNIA.

By W. C. MENDENHALL.

INTRODUCTION.

The greater part of the coastal plain of southern California is included in the Anaheim, Santa Ana, Downey, Las Bolsas, Santa Monica, and Redondo quadrangles[a] of the United States Geological Survey, and all of it is in Orange and Los Angeles counties. For convenience of treatment and discussion the coastal plain has been divided into an eastern, a central, and a western section, each section including two quadrangles. The eastern and central sections are described in Water-Supply Papers Nos. 137 and 138.

The westernmost section, which includes the Redondo quadrangle and the south half of the Santa Monica quadrangle, is described in this paper. The more important data are presented in the form of tables and maps; the tables giving the essential facts regarding each well examined, the maps showing graphically the irrigated areas, the attitude of the water plane, the extent and position of the past and present artesian areas, and the zones of relative purity of the ground waters.

In this area, which includes the largest body of water-bearing land, the largest artesian basin, and the most extensive diversified farming district of the southern part of the State, the development of underground waters for domestic purposes and irrigation has been under way for twenty-five years, but has been especially marked during the past decade.

By the valley of southern California is meant that lowland area that is limited on the north by the San Gabriel Range and is separated from the Mohave and Colorado deserts on the east by the San Bernardino and San Jacinto mountains. Toward the west it is open to the

[a] A quadrangle is the unit of survey adopted by the United States Geological Survey for the topographic and geologic atlas of the United States. It is a rectangular area 15 minutes, 30 minutes, or 1 degree in extent each way, bounded by parallels and meridians, and having an area of one-sixteenth, one-quarter, or 1 square degree. The quadrangles disregard political boundaries, such as those of States, counties, and townships. To each is given the name of some well-known place or feature within its limits. A sheet is a topographic map of one of the above areas.

Pacific, and on the south its limits are irregular and to a certain degree indefinite, the minor valleys into which the major valley divides in this direction gradually contracting and eventually practically disappearing in the general heights of the Sierra Madre.

This valley is more populous, is more intensely cultivated, and represents more concentrated wealth than any similar area in the entire Southwest. The basis for its wealth is its climate, which depends upon its physical geography and its latitude. Its southern situation is responsible for its moderately high mean annual temperature of about 62°; and the fact that it is open to the Pacific and is separated from the deserts to the north and east by high mountain ranges not only insures an equable distribution throughout the year of the mean temperature, but is an admirable provision for greater rainfall than is usual so far south on the Pacific coast. This combination of mild temperature and sufficient rainfall to provide for the cultivation of a large acreage, but not to destroy the beneficial effects of semiaridity with its large proportion of bright days and its dry air, makes the region most attractive as a place of residence. Furthermore, the soils are generally well disintegrated arid-land soils, not leached of their valuable soluble fertilizing constituents, so that with the artificial application of water they prove highly productive.

The valley of southern California is divided by the Santa Ana Mountains and their extension, the Puente Hills, into the coastal plain and the interior valley, each with its own minor peculiarities of soil and climate, and each exhibiting certain special phases of the problem which is common to southern California as to all arid and semiarid regions—the problem of water supply.

THE COASTAL PLAIN.

The coastal plain as a whole (see Pl. I) is about 50 miles in length in a northwest-southeast direction, and from 15 to 20 miles in width from the Pacific Ocean to the base of the Puente Hills and Santa Ana Mountains. It has an area of about 775 square miles. It is in general a region of low relief, and slopes gently seaward from an elevation of 200 or 300 feet along the inner edge to the salt marshes and sand dunes which border the Pacific. (Pl. II.) The chief interruptions to its level surface are San Pedro Hill, which rises distinctly above it but is not to be regarded as in any sense a part of it, and the low ridge which extends southeastward from the vicinity of Palms toward Huntington Beach. The most prominent heights along this ridge are the point just southeast of Palms, and Dominguez and Los Cerritos hills, 517, 195, and 364 feet in elevation, respectively. This ridge divides the coastal plain into an eastern and western section, alike as to climate, similar as to soils, but distinct as to underground conditions and the quantity and disposition of the ground waters.

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SALT MARSHES, SAND DUNES, AND SAND SPITS.
Near mouth of Ballona Creek.

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The inner edge of the plain is generally bench land, which contours the higher mountains back of it, forms bluffs (Pl. III, *A*) where the mountains approach the coast, and is dissected somewhat by the canyons of the small streams which cross it. These gullied benches are especially conspicuous back of Santa Monica and along the south base of the Santa Monica Mountains. Here they are composed of alluvium—stream-deposited sands, gravels, and clays—in contrast to the marine deposits which make up much of the coastal plain proper.

The eastern and central sections of the coastal plain, which have been discussed in Water-Supply Papers Nos. 137 and 138, include the greater part of the coastal plain artesian belt (Pl. I) and the lower courses of Los Angeles, San Gabriel, and Santa Ana rivers. The western section described here is crossed by none of the larger streams of the valley, and includes only the northwestern narrower part of the artesian area. It therefore contains a somewhat larger proportion of dry lands than the central and eastern areas. Its drainage generally is indefinite and ill defined, the valley of Ballona Creek being the only clearly marked drainage system in it. Along the coast is a belt of sand dunes which, in the section north of San Pedro Hill, extend inland for 2 miles in some instances, although these inner dunes are not now active.

South of Gardena is a depressed area without a surface outlet which has contained a lake 2 or 3 miles long during exceptionally wet years. At present this depression is dry. Other smaller pits are distributed along the old sand-dune belt back of the stretch of coast extending from Playa del Rey to Redondo.

SOILS AND CROPS.

The soils of this western section are generally fine in texture, contrasting strongly in this respect with many of the foothill soils of the valley farther inland nearer the high ranges. The dark loams with a notable percentage of humus are practically confined to the valley of Ballona Creek, to the marshes which extend northward from its mouth, and to an area which overlies the present or the original artesian basin, and is situated just south of the city of Los Angeles, in the vicinity of Slauson and Green Meadows. At a few points in the Ballona Valley these soils are slightly alkaline, but where free from injurious salts they are very fertile. Their fertilizing admixture of vegetable matter is due to the fact that they are or have been moist lands covered with a dense natural growth whose decay has yielded humus.

The upland soils are almost invariably sandy, although the sand sometimes contains a noticeable percentage of clay. The soils in the region extending from Inglewood to Wilmington are of this character, the purer and coarser sands lying nearer the coast and the clay

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Very respectfully,

F. H. NEWELL,
Chief Engineer.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

A. BLUFFS IN ALLUVIAL BENCH LANDS.

Inner edge of coastal plain.

B. CHARACTERISTIC ALLUVIUM OF SANTA MONICA BENCH LANDS.

plain it must percolate some distance underground, and even if its course is through very pervious materials the passage requires time, the capacity of all nearer gravels must be satisfied before it can be made, and all intervening developments lessen its amount. The coastal plain as a whole is the best watered large area and the largest well-watered area in the valley of southern California, but its western section is not so well situated relative to the principal sources as are the central and eastern sections. None of the larger streams cross it, although Los Angeles River flows near it and certainly contributes to its underground supplies.

Except for the flood waters contributed by Los Angeles River, this region, which includes the Redondo and the south half of the Santa Monica quadrangles, receives no water from the high mountains, which are so important a source of surface and of subsurface waters everywhere. With the exception of this contribution, it is dependent upon local rainfall and the comparatively limited run-off from the south slope of the Santa Monica Mountains.

Since there are no large flowing streams in the area, there are no very important surface systems of irrigation, such as originally utilized the flowing waters of Los Angeles River before the needs of the city absorbed it all, and such as now distribute the waters of the San Gabriel below the Paso de Bartolo and of the Santa Ana below Bedrock Canyon. The most important ditches are those that distribute well water, as does the flume of the Artesian Water Company that serves lands in the lower Ballona Creek Valley.

This company owns water-bearing lands near Cienega station, on the Santa Monica branch of the Southern Pacific Railroad, in which about 15 wells have been bored. The water from these wells, amounting to about 100 miner's inches, is conducted by a redwood flume, 8 or 9 miles long, 3¼ feet wide, and 2 feet deep, to the lands served in the middle and lower Ballona Creek Valley in the vicinity of Palms. The company was organized in 1900, with a capital stock of $250,000. The stock is not held by irrigators, but the company sells the water to them at a price of $10 per head for a 24-hour run, equal to 0.4 cent per hour-inch. For smaller quantities of water, 30 cents per hour for one-half head is charged, an advance of 50 per cent over the rates for larger quantities. The cost of the wells and the flume is reported at $50,000, and the total number of acres irrigated in 1904 is given as 750 - 400 in beans and the remainder in alfalfa and walnuts, there being but a small proportion of the latter.

Other shorter ditches are used to distribute the waters of Ballona Creek, and many of the pumping plants are connected with permanent wooden flumes or cement systems. Still other ditches distribute sewage from the Los Angeles outfall sewer or directly from the city system.

The greater part of the irrigation in the two quadrangles, however, is accomplished by means of the individual pumping plants, which are abundant throughout the lowlands south and southwest of Los Angeles, in an area originally artesian. A number of rather extensive local systems of this character have also been developed farther out upon the coastal plain in the vicinity of Gardena and Moneta.

UNDERGROUND WATER.

SOURCE.

Excluding the waters in the rock basins, the ultimate sources of all the ground waters are in the drainage areas of the streams which are tributary to the region. Thus the underground waters of the area north of the low ridge which divides the coastal plain are largely supplied by the drainage basin of Los Angeles River. When this stream discharges upon the coastal plain, after leaving the narrows at Los Angeles, its waters sink, and, spreading into a broad indefinite sheet, join the waters of the other rivers which flow out upon the coastal plain. Thus the coastal plain artesian basin is supplied. It is altogether probable that the moist lands about the station of Cienega, on the Southern Pacific Railroad, at the head of Ballona Creek, are thus supplied in large part by Los Angeles River water, and that the artesian wells in this neighborhood are also supplied largely by it, since it is the nearest of the greater coastal plain rivers.

It is not possible in general to tell where the boundary lies between those waters in an underground basin which are supplied from one source and those supplied from another, since the waters soon mingle and a definite boundary ceases to exist. Their behavior may very well be compared with that of two surface streams which unite. For a short distance below the junction the waters from each may be perfectly distinct, but the band of mingled waters along a median line becomes gradually broader until it extends from bank to bank. Then it can no longer be said of the water of any part of the stream that it is contributed exclusively by this or that tributary, since each has furnished a portion of it. The mingling of underground waters from distinct sources is precisely similar in character, but the process is much slower, since the rate of percolation is not as great as that of surface flow.

DISTRIBUTION OF UNDERGROUND WATER.

The interrupted ridge which extends northwest from Huntington Beach to the vicinity of Palms divides the coastal plain into an eastern and a western portion. Of these, the eastern portion has much the greater area. It includes the bigger part of the Downey, Anaheim, and Santa Ana quadrangles, while the western section occupies much of the Redondo quadrangle and a part of the Santa

Underground water - Effect of ridge on the wtr

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...... group of flowing wells in the vicinity of Sherman. Throughout the remainder of that part of the basin which is included in the Redondo and Santa Monica quadrangles, although water lies within easy pumping distance of the surface, the cheaper artesian waters can no longer be secured.

Another effect of this anticlinal ridge is to bring about great regularity in the ground-water levels above it. The hydrographic contours here indicate a moderate and generally regular slope of the water table. Below the ridge the slope is much less uniform, while within the broad area occupied by the ridge itself water levels are too erratic to be mapped with the slender evidence available.

Some of the winter flood waters, flowing as surface streams, escape across this ridge and reach the lower, drier lands toward the sea, where they are in part absorbed. It is probable also that, although this fold in the coastal plain clays and gravels acts as a dam, it is not uniformly impervious, and underground waters probably pass it to a certain limited extent. Such waters are contributed to the subsurface supply below the ridge, where they may be pumped.

Near the mouth of Ballona Creek is another small artesian basin, a few wells there tapping sand or gravel bodies which yield flowing water. Another small basin in the vicinity of Colegrove also yields flowing water, but from a consolidated sandstone of Tertiary age instead of from the loose sands and gravels which are the usual water-bearing media. These wells were bored for oil and are in some instances 1,000 feet or more in depth; not all equally deep wells in the vicinity, however, struck water under sufficient pressure to flow. It is not unusual to secure small flows from wells drilled for oil in the Tertiary beds of the Coast Range and foothills, but the yield is generally inferior to that from wells in the unconsolidated Pleistocene material of the

lowlands, and the water is almost invariably of poorer quality, since the Tertiary sands and shales are heavily impregnated with alkali salts. These rock waters, like the more abundant gravel waters, have their ultimate source in the rainfall; but, unlike the gravel waters, their circulation is not necessarily limited by drainage basins, since the rock structures favorable to percolation may extend from one drainage basin through an intervening range of hills to a neighboring basin.

These structures could be determined by detailed work and the underground courses of such waters and the intake at which they originate predicted, but as they are very limited in value and amount the results would not justify the work and expense. In the presence of so much freer sources they may in most cases be ignored.

PERMANENCE OF UNDERGROUND SUPPLY.

In all of the important basins of southern California during the last ten years there has been a general if varying fall in ground-water levels, a shrinkage of artesian areas, and a general reduction of yield from those artesian wells which continue to flow.

Rainfall, in inches, at Los Angeles, Cal.

Year.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr	May.	June.	Total.
1877-78	0.00	0.00	0.00	0.86	0.45	3.93	3.33	7.68	2.57	71	0.66	0.07	21.26
1878-79	.00	T.	.00	.14	T.	4.70	3.59	.97	49	19	.24	.03	11.35
1879-80	.00	.00	.00	.93	3.44	6.53	1.33	1.56	45	5.06	.04	.00	20.34
1880-81	T.	T.	.00	.14	.67	8.40	1.43	.36	66	46	.01	.00	13.13
1881-82	.00	T.	T.	.82	.27	.52	1.01	2.66	2.66	1.83	.63	T.	10.40
1882-83	.00	.00	T.	.05	1.82	.08	1.62	3.47	2.87	.15	2.02	.03	12.11
1883-84	T.	.00	.00	1.42	.00	2.56	3.15	13.37	12.36	3.54	.34	1.39	38.13
1884-85	T.	T	T.	.30	1.06	4.64	1.05	T.	.01	2.00	.06	T.	9.12
1885-86	T.	T.	T.	.26	5.52	1.63	7.72	1.38	2.50	3.29	.00	.01	22.31
1886-87	.21	.21	.00	.01	1.18	.18	0.20	9.25	.21	2.30	.20	.04	14.05
1887-88	.07	.00	.15	.12	.78	2.67	6.03	.77	3.15	.11	.02	T.	13.87
1888-89	.03	.08	T.	.36	4.01	6.26	.25	.92	6.18	.27	.62	.00	19.28
1889-90	.00	.61	.00	6.95	1.35	15.80	7.83	1.36	.66	.22	.03	.02	34.83
1890-91	.00	.03	.06	.03	.13	2.32	.25	8.56	.11	.26	.31	.00	12.36
1891-92	T.	.00	.06	.00	.00	1.99	.88	3.19	3.39	.22	2.06	.06	11.85
1892-93	.00	.01	.00	.33	1.10	4.18	6.29	2.27	8.52	.19	.06	.03	26.28
1893-94	.00	.00	T.	.75	.20	3.65	.94	.49	.37	.13	.20	T.	6.73
1894-95	T.	.01	.73	.02	.00	1.62	5.84	.46	3.77	.46	.19	.01	16.11
1895-96	T.	T.	T.	.24	.80	.78	3.23	T.	2.97	.19	.30	T.	8.51
1896-97	.02	.01	T.	1.30	1.66	2.12	3.70	5.62	2.31	.02	.10	T.	16.86
1897-98	T.	.00	.00	2.47	.01	.05	1.26	.51	.98	.03	1.75	T.	7.06
1898-99	.07	T.	.02	.09	T.	.12	2.64	.04	1.81	.18	.04	.58	5.59
1899-1900	.00	.01	T.	1.59	.90	.90	1.17	T.	.99	.54	1.81	T.	7.91
1900-1901	T.	T.	T.	.26	6.53	T.	2.49	4.38	.45	.68	1.50	T.	16.29
1901-02	T.	.09	.03	1.88	.16	T.	1.62	3.35	2.98	.16	.03	T.	10.60
1902-03	T.	T.	T.	.40	2.08	2.50	2.10	1.52	6.93	3.77	T.	.02	19.32
1903-04	.00	T.	.43	T.	0	T.	.14	2.68	4.50	.97	T.	T.	8.72

Average twenty-seven years, 15.35 inches.

The last ten years have been a period of low rainfall, the average at Los Angeles for the period being 25 per cent below the normal there. As a result the ground waters have been diminished by the decrease in the floods which supply them and by the increase in the drafts made upon them in order to make up the deficiency in stream flow. Hence an mportant part of the admitted shrinkage is justly chargeable to the dry period. But in some localities constant measurements on the water plane show that during the winters of 1900–1901 and 1902–3, during both of which the rainfall was above the average, the water level continued to fall, although at a much less rapid rate than during other drier years. At these places, therefore, it is evident that there should be no further increase of the drafts upon the underground waters, and that the reclaiming of lands from these as a source should cease.

In the western coastal plain area drafts have not yet become excessive, the wells being as yet relatively few in number.

In the Santa Monica quadrangle there are only about 25 flowing wells, yielding approximately 225 miner's inches of water, and, in 1903, only 134 pumping plants, most of them small, whose combined output during the pumping season certainly does not exceed 80 second-feet, equivalent to perhaps 15 or 20 second-feet continuous flow. This water is used for the towns and for somewhat less than 4,000 acres of irrigated lands.

In the Redondo quadrangle there are at present (1904) only 12 flowing wells, distributed over about 3.5 square miles, and about 200 pumping plants whose combined yield is probably 20 or 25 second-feet continuous flow. Three thousand two hundred and eighty acres are irrigated by sewage and about 8,250 acres from wells; this in a total irrigable area of perhaps 100 square miles.

In the two quadrangles more than $750,000 are invested in wells and pumps. The total area irrigated is 15,760 acres, the total amount of developed underground waters is between 40 and 50 second-feet, the original area of artesian lands is 28.4 square miles, the present (1904) artesian area is 8.7 square miles, and the total lowland area, much of which is not cultivated, is about 250 square miles. A part of the city of Los Angeles covers more than 22 square miles of this area, and the growing towns of Santa Monica, Ocean Park, Hollywood, Inglewood, Redondo, etc., occupy many more miles of it.

Although the quantity of water developed and the acreage irrigated by it are thus seen to be moderate, the local water supply is not controlled entirely by developments within the district considered, but is affected more or less by developments and diversions in adjacent regions. The shrinkage in that part of the coastal plain artesian basin which is included in the Redondo and Santa Monica

quadrangles, for instance, in so far as it is not due to drought, is probably due more to the complete diversion of Los Angeles River waters and to developments in the artesian basin farther east than to direct attacks on the ground waters in the areas in question.

The total number of flowing wells in the entire coastal plain artesian basin in 1904 was 2,500, and their yield is estimated at not less than 300 second-feet. The effect of this great drain in conjunction with the past decade of dry years has been to reduce the artesian area from about 290 to 190 square miles, the shrinkage taking place principally along the northern and northeastern borders of the basin, which first show the effects of a decrease in supply, for the same reason that water withdraws faster from the shallow upper end of a draining reservoir than from the lower deeper end. Hence in the Santa Monica and Redondo quadrangles the original area of 23 square miles is now reduced to 3.5 square miles.

The small Ballona basin, in which there are but four or five flowing wells, has not had serious drafts made upon it. Its situation, and the drainage tributary to it, should make it fairly resistant to reasonable drafts. The flowing wells about Colegrove are in deep-lying sandstones of Tertiary age and their life is difficult to estimate. The quality of these waters is not such as to invite their further exploitation so long as purer waters are obtainable.

With continued reasonable use of the underground waters of this area, then, it may be concluded that although the remnant of the coastal plain artesian basin included in it will probably disappear, because this basin is especially sensitive to distant diversions and developments, the ground waters generally will not suffer a serious permanent shrinkage.

DESCRIPTION OF MAPS AND TABLES.

The greater portion of the data concerning the wells in the Santa Monica and Redondo quadrangles has been assembled, as in the other reports on the coastal plain, in a set of tables (pp. 22-103), in which the character of each well, its depth, the depth of water in it, the proportion of dissolved salts in the water, the cost of well and machinery, the name and address of the owner, the location of the well, etc., are given. In these tables each well is designated by a number, and on the maps the number appears with each well symbol, so that when the wells in any locality are of interest to an engineer or rancher, by reference to the tables he can readily ascertain their character.

The artesian basins have been outlined and appropriately tinted (Pls. V and VI), the areas in which water now flows being distinguished from those in which it has ceased to flow by a difference in shading. Outside of the artesian areas the elevations of the water surface are indicated by hydrographic contours wherever there are sufficient data on which to base them.

Northeast of the Dominguez ridge the water plane is very regular and its position is readily determined. Southwest of this ridge it is much lower and over much of the area is quite irregular. In the Santa Monica quadrangle the irregularity is accounted for by the irregular deposition of the alluvium which makes the bench land south of the Santa Monica Mountains. (Pl. III, *B*). Between Ballona Creek and San Pedro Hill the irregularity is not so marked, probably because the sands and gravels which are water bearing there are coastal plain sediments and sand-dune material. The ridge which separates these two areas is one over which water levels are exceedingly erratic. There can be little question that it represents an anticline in the earlier coastal plain gravels, sands, and clays, and the irregularity in the attitude of the water-bearing strata is the cause of the irregularity in the waters themselves.

In those places where, because of these erratic water levels, or for other reasons, sufficient data have not been collected to serve as a basis for hydrographic contours, such facts as we have on water levels are indicated by figures. None of the water levels are more than approximately accurate, since none are instrumentally determined. The estimate of the elevation of a well head is based upon surface elevations, as indicated by the contours of the topographic sheet. Careful measurements were made in each instance from the well head to the water level in the well. The hydrographic contours thus are based upon and exhibit approximately the same degree of accuracy as the topographic contours. They should, therefore, be consistent with the latter throughout, and a comparison of the two should give approximately the depth of water at any point.

It is to be remembered, however, that in the neighborhood of pumping plants, especially in the western half of the coastal plain below the Dominguez ridge, where the water supply is not generally so large as above the ridge, rapid variations of as much as 10 feet take place in the water level with the starting and stopping of pumps. The contours are intended to represent an average condition at the time when the data were gathered.

The lands under irrigation during the winter of 1903–4 are shown by color on each of the sheets. (Pls. VII and VIII.) In the Santa Monica quadrangle 360 acres are irrigated by sewage, and about 3,880 acres by stream and well water. In the Redondo quadrangle 3,280 acres are irrigated by sewage, and about 8,240 acres by pumped and flowing waters; the total irrigated area in the two quadrangles is about 15,760 acres, or 24.5 square miles in a total of more than 175 square miles irrigable, if water were available.

There is a large acreage of dry land under successful cultivation, perhaps more than is under irrigation, so that the unirrigated lands are not by any means all waste. In addition, the growing towns and

cities occupy constantly expanding areas. Los Angeles alone now covers about 20.5 square miles in the Santa Monica quadrangle.

The amounts of salts dissolved in the well waters were determined approximately by means of the electrolytic bridge, the conductivity of the water increasing with the increase in alkalies. The results of these tests are given under appropriate headings in the tables. They have also been assembled in a purity map, in which waters are classified in three divisions. In one division are included those waters

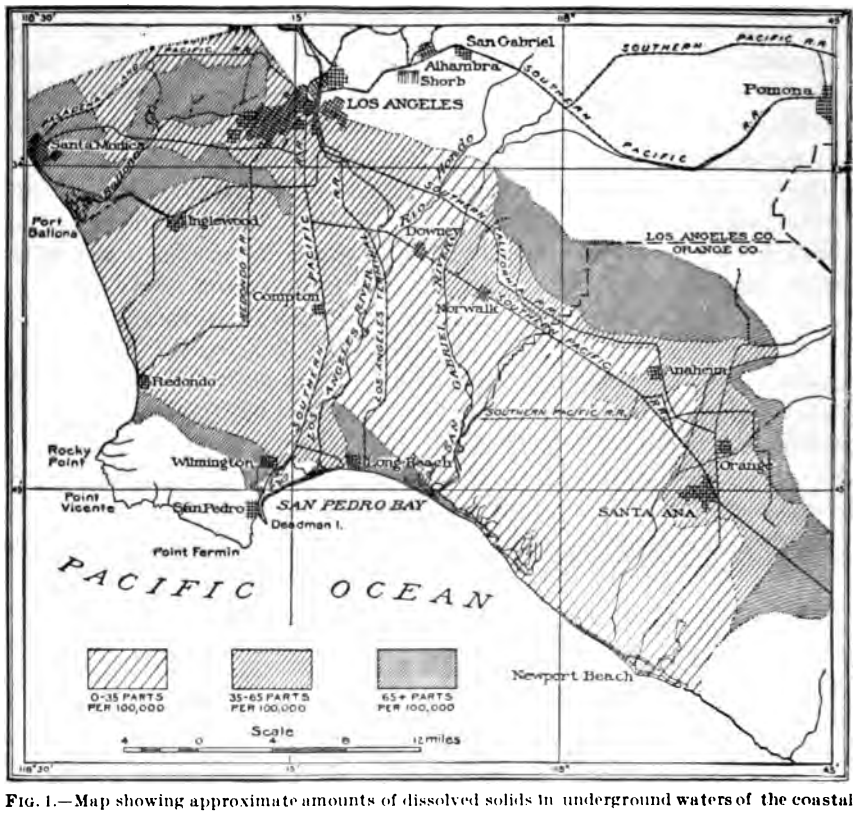

FIG. 1.—Map showing approximate amounts of dissolved solids in underground waters of the coastal plain region of southern California.

with less than 35 parts of dissolved matter in 100,000; in another are waters with from 35 to 65 parts of dissolved solids; and in the third are all waters containing more than 65 parts.

In the western section only waters of the last two classes occur, and the general distribution of the purity zones indicates a sluggish underground circulation as compared with those other parts of the coastal plain through which the greater part of the subsurface waters supplied by the Los Angeles, the San Gabriel, and the Santa Ana rivers passes. This inference follows directly from the fact that the purer waters are not sharply aligned in a definite relation to surface

streams as a source of supply, as is the case farther east. It is probable that the relatively slow movement of the underground waters in the western section, due to limited supply there, permits them to dissolve more of the soluble material from the sands and gravels through which they pass, and thus accounts for the greater proportion of salts which these western coastal plain waters contain. Yet a zone of relatively pure water extends from the Los Angeles River channel to the head of Ballona Creek and down the Ballona Valley to the Palms, below which it is cut off by the salt marshes of the coast. This may be supposed to be a direction of relatively free percolation.

To be strictly reliable as a guide only wells of considerable depth should be considered in the construction of purity maps, as shallow wells are so readily contaminated by the surface accumulation of alkalies. In the maps prepared for this report the records obtained from wells less than 25 feet deep have been disregarded, but even with this precaution the purity zones are no doubt somewhat influenced by surface conditions.

ACKNOWLEDGMENTS.

The greater part of the field work in the Redondo quadrangle, including the collection of well data and the mapping of irrigated lands, was done by Messrs. L. B. Brainard and A. P. McCarton, while Mr. Brainard covered the Santa Monica area, with the exception of a little late revision carried out by Mr. W. N. White.

Messrs. A. J. Fisk, jr., and W. N. White have been of much assistance in the office in the reduction of the material to form for publication. Owners of wells and plants and irrigating companies have responded readily to requests for records and information, and to them acknowledgments are due.

To Mr. Homer Hamlin, engineer of the reclamation service, who inaugurated the work whose results are published here, the writer is indebted for much helpful counsel, as well as for active supervision of much of the earlier field work.

WELL DATA.

Wells in Santa Monica quadrangle.

[* Cost of well and equipment combined. + Tank included, in column "Cost of machinery." † Yield estimated, or statement of owner taken. ? Doubtful.]

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
1	Peter Taylor	Los Angeles city	L-16	1898		165	130?	50	63	Wind		$350.00	Domestic	
2	Wm. Wibking	do	K-16, 17		Bored, 8-inch	163	128		65	do			do	
3	H. C. Turner	do	K-16		Bored, 12-inch	152	136			Compressed air			Irrigation	
4	do	do	K-16		Bored, 10-inch	152	136			do			do	
5	Mr. C. Jensen	do	K-17		Bored, 8-inch	150	131	47	53	Wind			Domestic	
6	J. C. Garnett	do	L-17	1882	Bored, 7-inch	172	136	107	54	do	$178.00	500.00	do	
7	James Larquier	do	L-17		Bored, 8-inch	170	95?	175	44	do			do	
8	W. J. Buckingham	do	L-17	1902	Bored, 7-inch	169	132	60	57	do		250.00	do	
9	L. Schlegel	Sec. 12, T. 2 S., R. 14 W.	L-17		Bored, 10-inch	169	136	80		Gas	480.00	1,160.00	Irrigation	† 110
10	do	do	L-17	1901	do	169	136	80	62	do				
11	do	do	L-17	1894	Bored, 8-inch	165	129	54	65	Wind	62.10	100.00	Domestic; irrigation.	
12	McGue Bros	do	L-17	1901	Bored, 8½-inch	150	127	425	49	Gas	1,500.00	2,000.00	Irrigation	166
13	do	do	L-17		Bored, 7-inch	157	126	46	52	Wind			Domestic	
14	Yost Lohsenger	do	L-17	1902	do	152	126	54	67	Hand	59.40		Domestic; stock	
15	L. Conneally estate	do	L-17	1902	do	151	126		67	Wind		350.00	Domestic	
16	John W. Downs	Los Angeles city	L-17	1902	do	157	130	58	62	do	72.00		do	
17	W. H. Dinsmore	do	L-17	1901	do	161	130	50		do	50.00	35.00	do	
18	Peter Shutt	do	L-17	1888	Bored, 6-inch	163	128	70	65	do	70.00	100.00	do	
19	James Crosby	do	L-17	1887	Bored 8-inch	164	128	180	61	do	207.00	400.00	Domestic; irrigation.	

22	Mrs. E. M. Young	Sec. 12, T. 2 S., R. 14 W.	K-17	1897	Bored, 8-inch										
23	Mr. Bosbyshell	Sec. 13, T. 2 S., R. 14 W.	K-17		Bored, 7-inch	141	128	41	61	Wind			Domestic; roads		
25	Wm. Dryden	Sec 11, T. 2 S., R. 14 W.	K-17	1880?	do	136	128	45	66	do	50.00		Domestic		
26	Paggi Bros	do	K-17	1897	do	130	126	36	66	do	40.00		Domestic; stock		
27	E. J. Baldwin	Paso De La Tijera	I-17	1896	do	135	134	96	41	do	100.00	200.00	Stock; domestic		
28	do	do	I-17	1878	do	195	Dry.	60							
29	do	do	J-17	1900	do	17	116	50	55	Wind	150.00		Stock		
30	R. Serrael	Los Angeles city	K-16	1900	Dug, 7 by 7 foot	155	131	27	44	do	150.00	150.00	Domestic		
31	West Side Water Co	do	K-16	1903	Bored, 12-inch	151	132	650					Not installed		
32	J. P. Riviere	do	K-16		Dug, 4 by 4 foot	147	108	40	65	Wind		60.00	Domestic		
33	Silvan Barges	do	K-16	1885	Bored, 7-inch	139	132	200+	50	Hand	700.00		Stock		
34	Earl R. Osborn	Sec. 2, T. 2 S., R. 14 W.	J-16	1902	Bored, 10-inch	140	125	256		Gas	700.00	1,300.00	Irrigation	†150	
35	do	do	J-16	1902	do	140	125	50		do			do		
36	do	do	J-16	1902	do	140	125	58		do			do		
37	Artesian Water Co	Sec. 3, T. 2 S., R. 14 W.	J-16	1900	Bored, 12-inch	131	125	347					Not used		
38	Earl R. Osborn	Sec. 2, T. 2 S., R. 14 W.	J-16	1897	Bored, 7-inch	141	126	142	53	Wind	175.00	125.00	Domestic		
39	Artesian Water Co	Sec 3, T. 2 S., R. 14 W.	J-16		Dug, 4 by 4 foot	141	126	30	47	do		100.00	do		
40	F. Benkert	Los Angeles city	K-15	1889	Bored, 8-inch	205	152	100	46	do			do		
41	Mrs. Childs	Sec. 2, T. 2 S., R. 14 W.	K-15			184	146	345	46	Gas			Domestic; irrigation		
42	J. L. Starr	do	K-16	1901	Bored	162	140	100	48	do	100.00		Stock; domestic		
43	Artesian Water Co	do	K-16		Bored, 6-inch	142	125	130		Wind			Not used		
44	Wm. Reid	Sec. 3, T. 2 S., R. 14 W.	J-16	1897	Dug, 4 by 4 foot	126	119	13	77	Hand	150.00		Domestic		
45	Artesian Water Co	do	J-16		Bored, 12-inch	137	125	100		Wind			Irrigation		
46	do	Las Cienegas	J-16		do	140	136		32	do			Domestic; stock		
47	do	do	I-16		do	116	116	307	59	Artesian			Irrigation		
48	do	do	I-16	1902	do	116	116	801	40	do			do		80
49	do	do	J-15	1896	Bored, 7-inch	145	135	233	50	Wind			Domestic		

Wells in Santa Monica quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
50	Artesian Water Co ...	Las Cienegas	I-16....	.....	Bored, 12-inch..	127	121	.....	56	Wind.....	.....	.....	Domestic; irrigation.	.....
51	Mr. D. Avila.....	.....do.....	I-15....	1902	Dug, 4 by 4 foot, 45 feet; bored, 7-inch, 135 feet.	165	125	180	72	.....do.....	$180.00	$75.00	Domestic.....	.....
52	F. Rimpan.....	.....do.....	I-16....	1903	Bored, 12-inch..	120	119	297	45	Artesian.....	500.00	.....	Irrigation.....	.....
53	A. Kravchyk.....	.....do.....	K-15....	1894	Bored, 8½-inch..	220	150	280	46	Gas.....	*1,000.00	.....	Irrigation; domestic.	.....
54	Thos. Higgins.....	Los Angeles city..	M-16....	1885	Bored, 8-inch...	200	136	64	.....	Wind.....	.....	.....	Domestic.....	.....
55	Wm. W. Carter.....	.....do.....	M-16....	1888	.....do.....	189	1477	64	63	.....do.....	.....	100.00	.....do.....	.....
56	Mrs. Simonsen.....	.....do.....	M-17....	.....	Bored, 7-inch...	187	134	63	60	.....do.....	.....	100.00	.....	.....
57	Chas. Mettler.....	.....do.....	M-17....	1902	Bored, 8-inch...	190	133	82	58	.....do.....	.....	150.00	Domestic.....	.....
58	Mrs. Messbaum.....	.....do.....	M-17....	1902	.....do.....	192	134	107	53	.....do.....	122.00	100.00	.....do.....	.....
59	H. Boettcher.....	.....do.....	N-16, 17.	.....	.....do.....	205	130	75	.....	.....do.....	.....	100.00	.....do.....	.....
60	Robert Matheson.....	.....do.....	N-16....	1893	Bored, 7-inch...	211	134	83	40	.....do.....	.....	100.00	.....do.....	.....
61	L. E. Shepherd.....	.....do.....	N-16....	1898	.....do.....	209	136	107	57	.....do.....	.....	.....	Domestic; irrigation.	
62	Wm. B. Brown.....	.....do.....	N-17....	1889	.....do.....	201	132	85	54	Hand.....	.....	.....	Domestic.....	.....
63	Mr. Birchfield.....	.....do.....	N-17....	.....	Bored, 6-inch...	193	133	110	40	Wind.....	.....	100.00	.....do.....	.....
64	Joseph Sweetapple....	.....do.....	N-17....	.....	Bored, 7-inch...	193	132	62	58	.....do.....	150.00	.....	.....do.....	.....
65	Dr. McCullough.....	.....do.....	N-17....	1900	Bored, 10-inch..	187	134	150	61	Gas.....	.....	1,800.00	Irrigation.....	.....
66	.....do.....	.....do.....	N-17....	.....	Bored, 7-inch...	184	132	60	66	Wind.....	100.00	.....	Domestic.....	.....
67	B. F. Buller.....	.....do.....	N-17....	.....	.....do.....	177	128	80	60	.....do.....	.....	100.00	.....do.....	.....
68	G. W. Kendall.....	.....do.....	N-17....	1882	.....do.....	181	126	60	68	.....do.....	.....	100.00	.....do.....	.....
69	Mrs. S. Lamphier.....	.....do.....	M-17....	.....	.....do.....	186	135	55	58	Hand.....	.....	.....	.....do.....	.....

	agents.														
71	Mrs. A. L. Acker	do	M-17	1900	do	180	136	51	71	do			Domestic; irrigation.		
72	N. C. Oswald	do	M-17	1902	Bored, 10-inch	175	133	230	61	Gas	310.50		Irrigation		
73	do	do	M-17	1902	do	175	133	72	61	do			do		
74	Mr. McNary	do	M-17		Bored, 7-inch	180	132	64	61	Wind			Domestic		
75	Chas. Rohr	do	N-17	1899	do	182	128	66	69	do	200.00		do		
76	Mrs. M. A. Burns	do	N-17		do	186		65	57	do			do		
77	John Redmond	do	N-17	1895	do	186	128	64	41	do	75.00	100.00	do		
78	O. F. Gehre	do	N-17		do	200	135	125	57	do		100.00	Domestic; irrigation.		
79	Daniel Tachet	do	N-17	1900	Dug, 4 by 4 foot	201	Dry.	56		do	300.00	100.00			
80	M. F. Moss	do	N-17		Bored, 7-inch	200	133	110	54	do		100.00	Domestic		
81	J. R. Gager	do	N-17	1901	Bored, 10-inch	201	141	171	58	Gas	*2,000.00		Domestic; irrigation.		
82	do	do	N-17	1900	do	201	141	70		Wind			Not used		
83	D. E. Muttersbaugh	do	N-17	1897	Bored, 7-inch	205	135	114	56	do	250.00	100.00	Domestic		
84	H. C. Simmons	do	M-17	1896	Bored, 6-inch	204	136	101	61	do			do		
85	M. P. Lucas	do	N-17	1895	Bored	208	134	79	57	do			do		
86	W. H. Merrill	do	N-17	1895	Bored, 7-inch	208	134	84		do		100.00	do		
87	Geo. Getchell	do	N-17	1883	do	204	138	84	57	do			do		
88	J. R. Dorsey	do	N-17	1901	Bored, 12-inch	204	138	211	52	Gas			Irrigation		120
89	L. E. Shepherd	do	N-17		Dug	204	Dry.	55							
90	James Oakley	do	N-17	1883	Bored, 7-inch	202	135	68		Wind	100.00	200.00	Not used		
91	J. Pauly	do	N-17		Bored, 8-inch	201	135	76	65	do	100.00	75.00	Domestic		
92	Guy Owen	do	N-17		do	204	Dry.	68							
93	G. J. Reinacker	do	N-17	1901	Bored, 6-inch	198	136	135	56	Wind	200.00	120.00	Domestic; irrigation.		
94	Sam Park	do	N-17	1901	Bored, 7-inch	199	136	130	58	do			Domestic		
95	H. Brewer	do	N-17	1899	Bored, 6-inch	198	146?	107	57	do			do		
96	T. A. Harris	do	N-17	1900	do	196	136	61		do	90.00	100.00	Not used		
97	Dr. M. S. Ertle	do	N-17	1892	Bored, 7-inch	197	134	63					do		
98	Mr. Sherwood	do	N-17		Bored, 6-inch	193		65		Wind		100.00	Domestic		
99	J. C. Scott	do	N-17	1886	Bored, 7-inch	193	136	70	57	do			do		
100	Dr. W. B. Wood	do	N-17		do	200	142	81	59	do		100.00	do		
101	A. L. Whitney	do	N-17	1883	do	201	143	64					Not used		

Wells in Santa Monica quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
102	E. M. Milsap	Los Angeles city	N-17	1898	Bored, 7-inch	202	142	65					Not used	
103	J. B. Okey	do	N-17	1895	do	190	130	64	61	Wind			Domestic	
104	M. E. Donavan	do	N-17	1901	do	188	1387	74	58	do	$100.00	$100.00	do	
105	W. E. Godsey	do	N-17	1902	do	195	139	74	56	do			do	
106	F. G. Gotts	do	M-17	1893	do	193	137	70	39	Hand			do	
107	W. C. Banks	do	M-17	1896	Bored, 8-inch	194	137	66	64	Wind			do	
108	P. J. Hummel	do	M-17	1885	Bored	184	133	60	59	do			do	
109	Geo. Worth	do	M-17		Bored, 6-inch	183	130	67	60	do			Domestic; stock	
110	A. H. Brocamp	do	M-17	1899	Bored, 9-inch	180	132	190		Gas	380.00	2,500.00	Irrigation	
111	N. Bartol	do	M-17	1884	Bored	180	120	90	63	Wind			Domestic	
112	Fred Espe	do	M-17	1900	Bored, 9-inch	174	134	64	73	Gas	200.00	825.00	Irrigation	
113	Mrs. Laura Carter	do	M-17	1898	Bored, 8-inch	173	132	49	73	Wind			Domestic	
114	John Thill	do	M-17	1895	Bored, 7-inch	175	135	49	61	do	100.00		do	
115	T. Schroeder	do	M-17	1900	do	175	135	52	64	do		100.00	do	
116	Irwin McGinnis	do	M-17	1900	do	177	134	61	67	do	75.00	75.00	do	
117	L. A. Postmaster	do	M-17		do	181	135	50	63	Hand			do	
118	Geo. Zobelein	do	M-17	1903	Bored, 8-inch	186	131	150	62	Gas			Domestic; irrigation.	
119	do	do	M-17	1901	Bored, 10-inch	188	133	190	57	Electric motor			Irrigation	
120	Agricultural Park Dairy.	do	M-17		Bored, 6-inch	185	126	73	62	Wind			Domestic	
121	W. T. Austermell	Sec. 7, T. 2 S., R. 13 W.	M-17	1895	do	176	135	60	58	do			Domestic; stock	
122	Mr. Thorpe	Los Angeles city	M-17		Bored, 8-inch	175	129	68	65	do			do	
123	F. H. Redpath	do	M-17	1903	do	175	129	53	63	do		75.00	Domestic	

													tion.
126	.....do.....	Sec. 7, T. 2 S., R. 14 W.	L-17....	1903	.....do.....	162	127	98	61	Hand.....	110.00	.....	Stock.....
127	Dr. Pratt.....	Los Angeles city..	M-16....	.....	.....	190	.....	.....	.....	Wind.....	.....	.....	Not used.....
129	C. T. Stewart.....	.....do.....	M-16....	1895	Bored, 7-inch...	188	133	66	64	.....do.....	.....	125.00	Domestic.....
130	Mrs. E. E. Brown...	.....do.....	L-16....	1896	Bored, 6-inch...	182	134	.....	56	.....do.....	.....	100.00	.....do.....
131	Mrs. L. S. Elliott.....	.....do.....	L-16....	1894	Bored, 7-inch...	182	133	96	57	.....do.....	.....	.....	.....do.....
132	Mrs. H. P. Andrews..	.....do.....	L-16....	1881	.....do.....	177	136	82	63	.....do.....	.....	100.00	.....do.....
133	Henry Knauff.....	.....do.....	M-16....	1888	Bored, 6-inch...	189	146?	100	92	.....do.....	135.00	100.00	.....do.....
134	Thos. Bones.....	.....do.....	L-16....	1894	Bored, 7-inch...	190	146	72	69	.....do.....	75.00	325.00	.....do.....
135	Dr. W. H. Palmer....	.....do.....	L-16....	1894	....do.....	185	Dry.	40	.....	.....do.....	60.00	500.00	Not used.....
136	Thos. Lloyd, agent....	.....do.....	L-16....	.....	Bored, 8-inch...	185	138	75	64	.....do.....	.....	.....	Domestic.....
137	Redondo Rwy. Co....	.....do.....	M-16....	1875	Bored, 6-inch...	196	135	113	61	.....do.....	.....	.....	Engines.....
138	Mrs. John Rey	.....do.....	L-16.....	.....	Bored, 8-inch...	184	135	61	58	.....do.....	.....	.....	Domestic.....
139	Agricultural Park	.....do.....	L-16, 17.	.....	.....do.....	177	.....	.....	.....	Gas.....	.....	.....	Roads.....
140	G. W. Guinn.....	.....do.....	L-16....	1889	Bored, 7-inch...	177	136	112	61	Wind.....	.....	.....	Domestic.....
141	A. Armbruster.....	Sec. 7, T. 2 S., R. 13 W.	L-17....	1895	Bored, 8-inch...	166	125	50	63	.....do.....	.....	100.00	.....do.....
142	Dr. F. J. Kruel.....	.....do.....	L-17....	.....	Bored, 7-inch...	160	126	57	65	.....do.....	.....	.....	Domestic; stock..
143	Mr. Butler.....	.....do.....	L-17....	.....	.....do.....	160	125	52	68	.....do.....	.....	.....	Domestic.....
144	H. A. Goldbach.....	Los Angeles city..	K-15....	1893	Bored, 8-inch...	213	141	270	54	.....do.....	.....	.....	.....do.....
145	Mr. Crippen.....	.....do.....	K-15....	.....	Bored, 7-inch...	209	140	89	54	.....do.....	.....	.....	.....do.....
146	F. W. Marshall.....	.....do.....	K-15....	1901	Bored, 10-inch..	198	130	235	129	Gas.....	400.00	1,500.00	.....do.....
147	Otto Wilhelm.....	Las Cienegas.....	J, K-15.	1902	Bored, 8-inch...	210	140	159	81	Wind.....	300.00	100.00	.....
148	Mr. Nelson.....	.....do.....	J-15....	1898	Bored, 7-inch...	220	145	156	54	.....do.....	.....	100.00	Domestic.....
149	Mrs. F. W. Sonnenburg.	.....do.....	J-15....	1896	Bored, 6-inch...	195	126	99	125	.....do.....	.....	.....	.....do.....
150	G. R. Reed.....	.....do.....	J-15....	1900	Bored, 18-inch, 50 feet; bored, 12-inch, 32 feet.	180	121	82	74	.....do.....	25.00	70.00	.....do.....
151	.....do.....	.....do.....	J-15....	1883	Bored, 7-inch...	180	121	90	74	.....do.....	125.00	400.00	.....do.....
152	Otto Wilhelm.....	.....do.....	J-15....	1901	Bored, 10-inch..	195?	130?	200	76	.....do.....	.....	100.00	Domestic; stock..
153	Max Byer.....	.....do.....	J-15....	1893	Bored.....	188	120	98	145	.....do.....	.....	.....	Domestic.....
154	Joseph Burkhart.....	.....do.....	J-15.....	.....	Bored, 7-inch...	174	123	82	.....	.....	.....	.....	Not used.....
155	Dr. Nadeau.....	.....do.....	J-15....	1887	Bored, 8-inch?..	180	64	174	72	Wind.....	.....	.....	Domestic.....

Wells in Santa Monica quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
156	Los Angeles County ..	Las Cienegas	J-15....	1899	Bored, 7-inch...	171	120	96	84	Wind.....	.....	.....	Stock; roads.....	.....
157	Nevada and California Real Estate Co.	.....do.....	J-15.....	.....	Bored, 8-inch...	161	121	62	67	.....do.....	.....	.....	Domestic.....	.....
158	O. H. Burbridge.....	Los Angeles city..	K-15....	.....	Bored, 7-inch...	220	136	88	.....	Not used.....	.....	.....	Not used	.....
159	M. L. Beardsley.....	.....do.....	K-15....	1899	.....do.....	220	136	235	47	Wind.....	$400.00	$100.00	Domestic.....	.....
160	Ferdinand Holm.....	.....do.....	K-15....	1881	Bored, 8-inch...	210	128	125	47	.....do.....	.....	.....	.....do.....	.....
161	C. F. Stuart.....	.....do.....	K-15....	1884	Bored, 7-inch...	205	137	87	54	.....do.....	90.00	200.00	.....do.....	.....
162	Mrs. F. Gason.....	.....do.....	K-15....	1892	Bored, 9-inch...	200	137	230	54	.....do.....	540.00	560.00	.....do.....	.....
163	Mrs. M. Mitchell.....	.....do.....	K-15....	1887	Bored, 7-inch...	201	137	100	70	.....do.....	.....	.....	.....do.....	.....
164	A. C. Eschrich.....	.....do.....	K-15....	.....	.....do.....	200	137	81	125	.....do.....	.....	.....	.....do.....	.....
165	Miss Kate Bagnall.....	.....do.....	L-15....	1888	Bored.....	206	137	79	101	.....do.....	.....	.....	.....do.....	.....
166	Mr. Orr.....	.....do.....	L-14, 15.	.....	Bored, 7-inch...	200	137	75	101	.....do.....	.....	.....	.....do.....	.....
167	John Bruckner.....	.....do.....	L-15....	1888	.....do.....	212	137	90	56	.....do.....	.....	.....	.....do.....	.....
169	Henry C. Jensen.....	.....do.....	K-15....	1887	.....do.....	200	143	82	56	.....do.....	.....	.....	.....do.....	.....
170	.....do.....	.....do.....	K-15....	.....	Dug, 4 by 4 foot, 66 feet; bored, 7-inch, 234 feet.	200	.....	300	.....	.....	.....	.....	Not used.....	.....
171	Leo Jouromsky.....	.....do.....	K-16....	1900	Bored, 7-inch...	163	130	100	39	Wind, gas.....	150.00	.....	Domestic; irrigation.	.....
172	F. A. Ripley.....	.....do.....	K-16....	1900	.....do.....	164	130	90	42	Wind.....	100.00	100.00	Domestic.....	.....
173	A. B. Tomlinsom	.....do.....	K-15.....	.....	.....do.....	220	136	149	...	Electric motor...	.....	350.00	.....do.....	.....
174	P. Pearson.....	.....do.....	L-15.....	1892	.....do.....	185	136	67	54	Wind.....	100.00	100.00	.....do.....	.....
175	J. W. Brown.....	.....do.....	L-15.....	.....	.....do.....	185	136	67	68	.....do.....	.....	.....	.....do.....	.....
176	R. Radford.....	.....do.....	L-15.....	.....	.....do.....	190	136	65	43	.....do.....	.....	.....	.....do.....	.....
177	A. Kosta.....	.....do.....	L-15.....	1895	.....do.....	190	135	83	39	.....do.....	.....	100.00	.....do.....	.....

178	*I. Wood*												
179	A. J. Franklin	do	L-15	1886	do	180	137	104	54	do	125.00		do
180	Mrs. F. Karpe	do	L-15	1883	do	185	137	63	50	do			do
181	Fred Fritz	do	L-16	1896	do	187	137	100	52	do	95.00	250.00	do
182	Harry Weiss	do	L-16	1900	do	182	137	225	56	Wind, gas	375.00	1,200.00	Domestic; irrigation.
183	Thos. W. Brown, sr.	do	L-16	1898	do	182	134	100	47	Wind	125.00	100.00	Domestic
184	E. A. Hoffman	do	L-16	1892?	do	177	139	75	56	do			do
185	Herbert J. Warner	do	L-16	1887	do	182	134	80	52	do	200.00		do
186	Tony Bright	do	L-16	1894	do	184	139	135	64	do	150.00	[a]1,200.00	do
187	Mrs. C. M. Yale	do	L-16	1898	do	183	139	260	74	do	300.00	150.00	do
188	W. J. Bryant	do	L-16	1898	do	178	138	45	70	do			do
189	R. A. Wiley	do	L-16	1897	do	175	138	55		do	75.00	100.00	do
190	Wm. Rudge	do	L-16	1897	do	169	134	51	58	do	56.00	65.00	do
191	J. W. Dodge	do	L-16	1897	do	168	138	74	63	do	78.00	70.00	do
192	Mrs. E. A. Northrop	do	L-16	1889	do	165	135	47	51	do	50.00	100.00	do
193	G. H. Paine	do	K-16	1897	do	164	135	79	58	do	100.00	100.00	do
194	W. M. March	do	K-16		do	157	131	47	57	do			do
195	H. G. Spottswood	do	L-16	1897	do	175	139	64	59	do	70.00	75.00	do
196	J. E. Mahoney	do	L-16	1894	do	168	134	78	68	do	105.00		do
197	G. W. Hood	do	K-16		do	167	131	73	45	do			do
198	Mrs. Emelie Hertel	do	K-16	1897	do	157	130	60	41	do	60.00	75.00	do
199	C. W. Johnston	do	K-16	1901	do	157	131	48	53	Hand			Not used
200	Lee McConnell	do	K-16	1896	Dug, 3½ by 3½ foot.	150	130	21	81	do	25.00		Domestic
201	A. E. Guinn	do	L-16	1895	Bored, 7-inch	172	130	65	57	Wind			do
202	Dr. Wylie	La Brea	J-11		do	342	274	137	59	do			do
203	F. L. Dodge	do	J-11	1897	do	314	275	52	58	do			do
204	H. Kettle	do	J-11	1900	Dug, 6 by 4 foot.	297	270	37	54	Gas			Domestic; irrigation.
205	N. A. Watson	do	J-11	1895	Bored, 7-inch	313	274	50	56	Wind	50.00	200.00	Domestic
206	F. L. Dodge	do	J-11	1899	Bored	298	270	46	50	do	50.00	250.00	do
207	R. H. Jones	do	J-12	1892	Bored, 7-inch	334	279	160	65	Gas	230.00	450.00	Domestic; irrigation.
209	Mrs. Ida Henkle	do	J-12	1885	Dug, 3 by 3 foot.	280	Dry.	35					

[a] Includes cost of tank house.

Wells in Santa Monica quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
208	Mrs. Ida Henkle	La Brea	J-12	1899	Dug, 4 by 6 foot, 24 feet; bored, 9-inch, 16 feet.	280	263	40	60	Gas	$100.00	$400.00	Domestic	†7
210	A. C. Haley	do	J-12	1899	Bored, 7-inch	272	250	25	56	Wind	35.00	50.00	do	
211	Mrs. E. G. Eckhart	do	J-12		do	279	229	53	53	do			do	
212	Mr. C. Cole	do	J-11		do	296	272	47	54	do			do	
213	James Warren	Los Feliz	L-11	1890	do	420	329	112	54	do			Domestic; irrigation.	
214	do	do	L-11	1895	do	417	329	167	34	Gas			Irrigation	
215	Martin Stoll	do	L-11	1902	Bored	422	329	126	26	Wind			Domestic	
216	Mrs. S. Whitman	do	L-11	1895?	Dug, 3-foot diameter.	401	330	72	24	do			do	
217	Mrs. Anna Baumeister	do	L-11	1895	do	375	318	62	26	Hand			do	
218	C. S. Billman	do	L-11	1903	Bored, 6-inch	370	315	81	38	do	61.00	27.00	do	
219	L. H. Price	do	L-10	1889	Dug, 6-foot diameter.	480	468	22	31	Gas			Domestic; irrigation.	
220	C. J. Griffith	do	L-10	1892	Dug, 3-foot diameter.	480	459	40	31	Hand			Domestic	
221	Mrs. Mary Martin	do	L-10	1890	Bored, 7-inch	550	501	100	26	Wind	130.00	150.00	do	
222	L. Salter	do	L-10	1899	Dug, 4½-foot diameter.	555	510	48	22	Gas	75.00	250.00	Domestic; irrigation.	
223	W. H. Hoegee	do	L-10	1902	Bored, 8-inch	540		370		do			do	
224	G. W. Price	do	L-10	1887	Dug, 6 by 4 foot	500	468	40	41	Wind		100.00	Domestic	
225	Morgan Griffith	do	L-10	1901	Bored, 7-inch	500	450	125	19	Gas	125.00		Domestic; irrigation.	
226	C. F. Fosdick	do	L-10	1897		500	453	72		Wind	100.00	100.00	do	
227	S. A. Leaverton	do	L-10		Bored, 7-inch	510	482	80	26	do	100.00	75.00	Domestic	

					ameter.										
229	....do	....do	L-10	1902	Bored, 12-inch	510	488	254	28	Gas	472.00	500.00	....do	†5
230	Wm. Gregory	....do	L-10		Bored, 16-inch	510	496	50	27	Wind		100.00	....do	
231	Ambrose Gregory	....do	L-10	1883	Bored, 7-inch	500	495	300	25	Gas	400.00	400.00	....do	
232	T. Brotherton	....do	L-10	1883?	....do	500	493	325		Tunnel			....do	
233	....do	....do	L-10	1883?	....do	500	493	120?		....do			....do	
234	Little & Warren	....do	L-10		....do	490	485	50		....do			....do	
235	....do	....do	L-10		Bored, 12-inch	490	485	50		....do			....do	
236	....do	....do	L-10		Bored, 7-inch	490	485			....do			....do	
237	....do	....do	L-10		....do	490	485						....do	
238	....do	....do	L-10		....do	490	485						....do	
239	W. S. Sutton	....do	L-10	1901	....do	490	485	90	25	Gas			....do	
240	....do	....do	L-10	1901	Bored, 16-inch	490	485	90	24	....do			....do	
241	....do	....do	L-10	1896	Bored, 7-inch	480	479	102		Wind	I25.00	100.00	Domestic	
242	J. L. Sledzianoski	....do	L-10	1895?	....do	450	432	100	31	....do			....do	
243	District school	....do	L-10		....do	520	478	67						
244	Mr. Griffith	....do	L-10	1902	Bored, 12-inch	480	437	94	28	Hand			Domestic	
245	W. E. Cummings	....do	L-10	1897	Dug, 3 by 4½ foot	480	451	41	34	Gas, wind			Domestic; irrigation.	
247	Homer Laughlin	....do	K-10	1901	Bored, 12-inch	485	465	400	48	Wind	2,000.00	100.00	Irrigation	
248	T. A. Fry	....do	K-10	1902	Bored, 5¼-inch	490	468	60	53	....do	75.00	100.00	Domestic	
249	Homer Laughlin	....do	K-10	1902	Bored, 7⅝-inch	470	461	60			75.00		Not installed	
250	E. L. Allen	....do	K-10	1893	Bored, 7-inch	440	362	98		Wind			Domestic	
251	W. E. Cummings	....do	L-10	1897	....do	500	452	68	36				Not used	
252	E. L. Allen	....do	K-10	1901	Bored, 10-inch	440	263	200+					....do	
253	Mr. Griffith	....do	L-10	1902	Bored, 16-inch	440	359	1,100					....do	
254	....do	....do	L-10	1897	Bored, 6-inch	440	379	121	32	Gas			Irrigation	
255	....do	....do	L-10		Bored, 12-inch	450	446	146	72				Not used	
256	Peter Tanner	....do	L-10,11	1899	Bored, 7-inch	430	370	225	72	Gas	350.00	600.00	Domestic; irrigation.	
257	Geo. H. Stoll	....do	L-10,11		....do	425	343	95	67	Wind			....do	
258	S. Taylor	....do	L-10	1890	....do	425	361	102	35	....do			....do	
259	J. M. Gelb	....do	L-10	1898	....do	434	342	126	30	Gas	200.00	200.00	Irrigation	
260	J. A. Lewis	....do	L-10	1901	....do	445	408	76	36	Wind			Domestic	

Wells in Santa Monica quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
261	D. M. Little	Los Felis	L-10	1893?	Dug, 3-foot diameter.	460	433	24	68	Wind			Domestic; irrigation.	
262	Mrs. H. E. Newton	do	L-10	1883	Bored, 7-inch	440	364	120	32	do	$125.00	$200.00	Domestic	
263	H. A. Bourne	do	L-11	1883	Bored, 8-inch	430	351	88	29	do			do	
264	R. M. Tull	do	K, L-11	1895	Bored, 7-inch	384	304	197	43	Gas	*1,000.00		Domestic; irrigation.	
265	E. A. Eaton	do	K-11	1890	do	390	313	162	44	do	200.00	250.00	do	
266	Mrs. Caroline Lamb	do	K-11	1890	do	405	320	156	54	Wind, gas	200.00		do	
267	Mrs. E. B. Wakeman	do	K-11		do	400	320	140		Gas			do	
268	Lewis Ferry	do	K-11	1895	do	386	306	287	48	do	500.00	600.00	do	†6
269	J. V. Dodds	do	K-11	1893	do	386	288	191	49	Wind	273.00	300.00	Domestic	
270	J. H. Devol	do	K-11	1894	do	382	277	195	52	do	300.00	200.00	do	
271	Reyes Bros	Sec. 11, T. 1 S., R. 14 W.	K-11	1901	do	370	280	249	53	Gas	385.00		Irrigation	†3
272	G. W. Warner	do	K-11		do	354	271	98	60	Wind	120.00	100.00	Domestic	
273	W. C. Fry	do	K-11	1894	do	347	277	275	44	Compressed air	425.00	3,400.00	Irrigation	
274	do	do	K-11	1888	do	351	296	108	33	Wind	125.00	200.00	Domestic	
275	E. C. Hampton	Los Felis	K-11	1900	do	365	200	237	35	Gas	300.00	900.00	Domestic; irrigation.	†8
276	H. K. Vickroy	do	K-11	1896	do	370	290	291	35	do	480.00		Irrigation; domestic.	†8
277	H. Dwire	do	K-11	1901	do	370	290	300	33	do	900.00		do	
278	do	do	K-11	1901	do	370	290	380			800.00		Not used	
279	Mrs. K. T. McFadden	do	L-11	1900?	Bored, 8-inch	365	310	698	24	Wind	1,200.00	200.00	Domestic	
280	E. F. Bogartis	do	K-11		Bored, 7-inch	360	287	180	40	do	250.00	125.00	do	

281	L. A. McCray	do	K-11	1888	do	365	286	150	50	do	175.00	100.00	Domestic; irrigation.		
282	A. H. Mann	do	K-11	1900	do	338	276	124	44	do	135.00	150.00	Domestic		
283	U. Remida	do	K-11	1892	Dug, 4-foot diameter.	339	277	64	42	Hand			do		
284	C. Cole	Sec. 11, T. 1 S., R. 14 W.	J-11	1897	Bored, 7-inch	357	285	283	54	Gas	500.00	500.00	Irrigation		
285	Mrs. M. C. Gower	do	J-11	1883	do	350	290	72		Wind, gas			Domestic; irrigation.		
286	Mr. M. Labaig	do	J-11	1885	do	367	281	126		Wind	150.00	100.00	Domestic		
287	Mrs. R. Blondeau	do	J-11	1889	do	358	283	92		do			do		
288	O. S. Adams	La Brea	J-11	1898	do	347	284	200	54	do	250.00	150.00	do		
289	H. D. Wilkerson	Sec. 10, T. 1 S., R. 14 W.	J-11	1898	do	350	268	100		do	100.00		do		
290	A. L. Reyes	do	J-11	1899	do	360	290	150	54	Gas	175.00	300.00	Domestic; stock		
291	H. D. Wilkerson	do	J-11	1900	do	365	268	160	77	Wind			Domestic		
292	H. J. Whitley	do	J-11		do	360	260	385	86	Compressed air			Irrigation		
293	Hollywood Cemetery Association.	Sec. 14, T. 1 S., R. 14 W.	J-11	1896	Bored, 10-inch	310	277	85	26	Electric motor			Domestic; irrigation.		
294	W. J. Fay	La Brea	J-11	1903	Bored, 6-inch	309	277	65	33	Wind	65.00	50.00	Domestic		
295	C. W. Walker	do	J-11	1893	Bored, 7-inch	355	265	190	87	Gas	250.00	200.00	Domestic; irrigation.		†2
296	Warren Campbell	do	J-11		do	337	265	93		Wind			Not used		
297	W. Squire	do	J-11	1900	do	348	258	285	84	Gas	407.00	1,000.00	Irrigation		
298	Miss Winsstanley	do	J-11	1897	do	348	258	300	69	Wind			Domestic		
299	Mrs. E. J. Boyle	do	J-11		do	332	261	138	72	do	200.00	150.00	do		
300	T. Davidson	do	I-11		do	350	261	191	71	do	225.00	150.00	do		
301	A. Z. Taft	Sec. 11, T. 1 S., R. 14 W.	K-11	1893	do	398	271	297	57	do	520.00	215.00	do		
302	E. D. Sturdevant	Los Feliz	K-10	1902	do	425	300	228	60	Gas	360.00		Domestic; irrigation.		
303	Ashton Fry	do	K-10		Dug, 3-foot diameter.	450	448	9	53	Siphon			Irrigation		
304	do	do	K-10		Dug, 6-foot diameter.	450	443	17	43	do			do		
305	M. Audroda	Sec. 2, T. 1 S., R. 14 W.	K-10	1884	Bored, 7-inch	440	396	60			75.00		Not used		
306	I. W. Lord	do	K-10	1888	Dug, 3 by 3 foot	460	486	17	131	Hand			Domestic		

WELL DATA.

Wells in Santa Monica quadrangle.

[* Cost of well and equipment combined. + Tank included, in column "Cost of machinery." † Yield estimated, or statement of owner taken. ? Doubtful.]

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
1	Peter Taylor	Los Angeles city	L-16	1898		165	130?	50	63	Wind		$350.00	Domestic	
2	Wm. Wibking	do	K 16, 17		Bored, 8-inch	163	128		65	do			do	
3	H. C. Turner	do	K-16		Bored, 12-inch	152	136			Compressed air			Irrigation	
4	do	do	K-16		Bored, 10-inch	152	136			do			do	
5	Mr. C. Jensen	do	K 17		Bored, 8-inch	150	131	47	53	Wind			Domestic	
6	J. C. Garnett	do	L 17	1882	Bored, 7-inch	172	136	107	54	do	$178.00	500.00	do	
7	James Larquier	do	L-17		Bored, 8-inch	170	95?	175	44	do			do	
8	W. J. Buckingham	do	L-17	1902	Bored, 7-inch	169	132	60	57	do		250.00	do	
9	L. Schlegel	Sec. 12, T. 2 S., R. 14 W.	L-17		Bored, 10-inch	169	136	80		Gas	480.00	1,160.00	Irrigation	† 110
10	do	do	L-17	1901	do	169	136	80	62	do				
11	do	do	L-17	1894	Bored, 8-inch	165	129	54	65	Wind	62.10	100.00	Domestic; irrigation.	
12	McGue Bros	do	L 17	1901	Bored, 8½-inch	150	127	425	49	Gas	1,500.00	2,000.00	Irrigation	166
13	do	do	L-17		Bored, 7-inch	157	126	46	52	Wind			Domestic	
14	Yost Lohsenger	do	L-17	1902	do	152	126	54	67	Hand	59.40		Domestic; stock	
15	L. Connealy estate	do	L-17	1902	do	151	126		67	Wind		350.00	Domestic	
16	John W. Downs	Los Angeles city	L-17	1902	do	157	130	58	62	do	72.00		do	
17	W. H. Dinsmore	do	L-17	1901	do	161	130	50		do	50.00	35.00	do	
18	Peter Shutt	do	L-17	1888	Bored, 6-inch	163	128	70	65	do	70.00	100.00	do	
19	James Crosby	do	L-17	1887	Bored 8-inch	164	128	180	61	do	207.00	400.00	Domestic; irrigation.	

20	Mrs. Geo. Lynch	....do	K-17	1902	Bored, 6-inch	160	130	32	61	....do	25.00	50.00	....do	
21	Mrs. A. G. Gardner	....do	K-17	1880	Bored, 7-inch	153	133	39	68	....do			Domestic	
22	Mrs. E. M. Young	Sec. 12, T. 2 S., R. 14 W.	K-17	1897	Bored, 8-inch	146	136?	40?	69	Hand	40.00	25.00	....do	
23	Mr. Bosbyshell	Sec. 13, T. 2 S., R. 14 W.	K-17		Bored, 7-inch	141	128	41	61	Wind			Domestic; roads	
25	Wm. Dryden	Sec 11, T. 2 S., R. 14 W.	K-17	1880?	....do	136	128	45	66	....do	50.00		Domestic	
26	Paggi Bros	....do	K-17	1897	....do	130	126	36	66	....do	40.00		Domestic; stock	
27	E. J. Baldwin	Paso De La Tijera	I-17	1896	....do	135	134	96	41	....do	100.00	200.00	Stock; domestic	
28	....do	....do	I-17	1878	....do	195	Dry.	60						
29	....do	....do	J-17	1900	....do	117	116	50	55	Wind	150.00		Stock	
30	R. Serrael	Los Angeles city	K-16	1900	Dug, 7 by 7 foot	155	131	27	44	....do	150.00	150.00	Domestic	
31	West Side Water Co	....do	K-16	1903	Bored, 12-inch	151	132	650					Not installed	
32	J. P. Riviere	....do	K-16		Dug, 4 by 4 foot	147	108	40	65	Wind		60.00	Domestic	
33	Silvan Barges	....do	K-16	1885	Bored, 7-inch	139	132	200+	50	Hand	700.00		Stock	
34	Earl R. Osborn	Sec. 2, T. 2 S., R. 14 W.	J-16	1902	Bored, 10-inch	140	125	256		Gas	700.00	1,300.00	Irrigation	†150
35	....do	....do	J-16	1902	....do	140	125	50		....do			....do	
36	....do	....do	J-16	1902	....do	140	125	58		....do			....do	
37	Artesian Water Co	Sec. 3, T. 2 S., R. 14 W.	J-16	1900	Bored, 12-inch	131	125	347					Not used	
38	Earl R. Osborn	Sec. 2, T. 2 S., R. 14 W.	J-16	1897	Bored, 7-inch	141	126	142	53	Wind	175.00	125.00	Domestic	
39	Artesian Water Co	Sec 3, T. 2 S., R. 14 W.	J-16		Dug, 4 by 4 foot	141	126	30	47	....do		100.00	....do	
40	F. Benkert	Los Angeles city	K-15	1889	Bored, 8-inch	205	152	100	46	....do			....do	
41	Mrs. Childs	Sec. 2, T. 2 S., R. 14 W.	K-15			184	146	345	46	Gas			Domestic; irrigation.	
42	J. L. Starr	....do	K-16	1901	Bored	162	140	100	48	....do	100.00		Stock; domestic	
43	Artesian Water Co	....do	K-16		Bored, 6-inch	142	125	130		Wind			Not used	
44	Wm. Reid	Sec. 3, T. 2 S., R. 14 W.	J-16	1897	Dug, 4 by 4 foot	126	119	13	77	Hand	150.00		Domestic	
45	Artesian Water Co	....do	J-16		Bored, 12-inch	137	125	100		Wind			Irrigation	
46	....do	Las Cienegas	J-16		....do	140	136		52	....do			Domestic; stock	
47	....do	....do	I-16		....do	116	116	307	59	Artesian			Irrigation	
48	....do	....do	I-16	1902	....do	116	116	801	40	....do			....do	50
49	....do	....do	J-15	1896	Bored, 7-inch	145	135	233	50	Wind			Domestic	

WELL DATA.

Wells in Santa Monica quadrangle.

[* Cost of well and equipment combined. + Tank included, in column "Cost of machinery." † Yield estimated, or statement of owner taken. ? Doubtful.]

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
1	Peter Taylor	Los Angeles city	L-16	1898		165	1307	50	63	Wind		$350.00	Domestic	
2	Wm. Wibking	do	K-16, 17		Bored, 8-inch	163	128		65	do			do	
3	H. C. Turner	do	K-16		Bored, 12-inch	152	136			Compressed air			Irrigation	
4	do	do	K-16		Bored, 10-inch	152	136			do			do	
5	Mr. C. Jensen	do	K-17		Bored, 8-inch	150	131	47	53	Wind			Domestic	
6	J. C. Garnett	do	L-17	1882	Bored, 7-inch	172	136	107	54	do	$178.00	500.00	do	
7	James Larquier	do	L-17		Bored, 8-inch	170	957	175	44	do			do	
8	W. J. Buckingham	do	L-17	1902	Bored, 7-inch	169	132	60	57	do		250.00	do	
9	L. Schlegel	Sec. 12, T. 2 S., R. 14 W.	L-17		Bored, 10-inch	169	136	80		Gas	480.00	1,160.00	Irrigation	† 110
10	do	do	L-17	1901	do	169	136	80	62	do				
11	do	do	L-17	1894	Bored, 8-inch	165	129	54	65	Wind	62.10	100.00	Domestic; irrigation.	
12	McGue Bros	do	L-17	1901	Bored, 8½-inch	150	127	425	49	Gas	1,500.00	2,000.00	Irrigation	166
13	do	do	L-17		Bored, 7-inch	157	126	46	52	Wind			Domestic	
14	Yost Lohsenger	do	L-17	1902	do	152	126	54	67	Hand	59.40		Domestic; stock	
15	L. Conneally estate	do	L-17	1902	do	151	126		67	Wind		350.00	Domestic	
16	John W. Downs	Los Angeles city	L-17	1902	do	157	130	58	62	do	72.00		do	
17	W. H. Dinsmore	do	L-17	1901	do	161	130	50		do	50.00	35.00	do	
18	Peter Shutt	do	L-17	1888	Bored, 6-inch	163	128	70	65	do	70.00	100.00	do	
19	James Crosby	do	L-17	1887	Bored 8-inch	164	128	180	61	do	207.00	400.00	Domestic; irrigation.	

20	Mrs. Geo. Lynch	do	K-17	1902	Bored, 6-inch	160	130	32	61	do	25.00	50.00	do	
21	Mrs. A. G. Gardner	do	K-17	1880	Bored, 7-inch	153	133	39	68	do			Domestic	
22	Mrs. E. M. Young	Sec. 12, T. 2 S., R. 14 W.	K-17	1897	Bored, 8-inch	146	136?	40?	69	Hand	40.00	25.00	do	
23	Mr. Bosbyshell	Sec. 13, T. 2 S., R. 14 W.	K-17		Bored, 7-inch	141	128	41	61	Wind			Domestic; roads	
25	Wm. Dryden	Sec. 11, T. 2 S., R. 14 W.	K-17	1880?	do	136	128	45	66	do	50.00		Domestic	
26	Paggi Bros	do	K-17	1897	do	130	126	36	66	do	40.00		Domestic; stock	
27	E. J. Baldwin	Paso De La Tijera	I-17	1896	do	135	134	96	41	do	100.00	200.00	Stock; domestic	
28	do	do	I-17	1878	do	195	Dry.	60						
29	do	do	J-17	1900	do	117	16	50	55	Wind	150.00		Stock	
30	R. Serrael	Los Angeles city	K-16	1900	Dug, 7 by 7 foot	155	131	27	44	do	150.00	150.00	Domestic	
31	West Side Water Co	do	K-16	1903	Bored, 12-inch	151	132	650					Not installed	
32	J. P. Riviere	do	K-16		Dug, 4 by 4 foot	147	108	40	65	Wind		60.00	Domestic	
33	Silvan Barges	do	K-16	1885	Bored, 7-inch	139	132	200+	50	Hand	700.00		Stock	
34	Earl R. Osborn	Sec. 2, T. 2 S., R. 14 W.	J-16	1902	Bored, 10-inch	140	125	256		Gas	700.00	1,300.00	Irrigation	†150
35	do	do	J-16	1902	do	140	125	50		do			do	
36	do	do	J-16	1902	do	140	125	58		do			do	
37	Artesian Water Co	Sec. 3, T. 2 S., R. 14 W.	J-16	1900	Bored, 12-inch	131	125	347					Not used	
38	Earl R. Osborn	Sec. 2, T. 2 S., R. 14 W.	J-16	1897	Bored, 7-inch	141	126	142	53	Wind	175.00	125.00	Domestic	
39	Artesian Water Co	Sec 3, T. 2 S., R. 14 W.	J-16		Dug, 4 by 4 foot	141	126	30	47	do		100.00	do	
40	F. Benkert	Los Angeles city	K-15	1889	Bored, 8-inch	205	152	100	46	do			do	
41	Mrs. Childs	Sec. 2, T. 2 S., R. 14 W.	K-15			184	146	345	46	Gas			Domestic; irrigation	
42	J. L. Starr	do	K-16	1901	Bored	162	140	100	48	do	100.00		Stock; domestic	
43	Artesian Water Co	do	K-16		Bored, 6-inch	142	125	130		Wind			Not used	
44	Wm. Reid	Sec. 3, T. 2 S., R. 14 W.	J-16	1897	Dug, 4 by 4 foot	126	19	13		Hand	150.00		Domestic	
45	Artesian Water Co	do	J-16		Bored, 12-inch	137	125	100		Wind			Irrigation	
46	do	Las Cienegas	J-16		do	140	136		52	do			Domestic; stock	
47	do	do	I-16		do	116	16	307	59	Artesian			Irrigation	
48	do	do	I-16	1902	do	16	16	801	40	do			do	50
49	do	do	J-15	1896	Bored, 7-inch	145	135	233	50	Wind			Domestic	

Wells in Santa Monica quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
393	S. C. Stevenson	Sec. 12, T. 1 S., R. 14 W.	K. L-11.	1903	Bored, 6-inch	320	280	61	29	Hand	$45.75		Domestic	
394	Mr. Cornell	do	K. L-11.	1903	do	340	286	60	41		45.00		Not installed	
395	R. C. Kuestner	Sec. 13, T. 1 S., R. 14 W.	K-12	1898	Dug, 4 by 4 foot.	310	270	50	40	Wind	75.00	$100.00	Domestic	
396	Clara Lawrence	do	K 12		Bored, 7-inch	315	286	48	59	do	50.00	75.00	do	
397	Fred F. Wheeler	Los Angeles city.	M-13.	1895	Bored, 7⅝-inch	305	303	500	150+	do	1,200.00	125.00	Irrigation	
398	L. A. P. Rwy. Co	do	L-13	1903	Bored, 9¾-inch	250		300+						
399	A. H. Hedley	do	M 12	1902	Bored, 7⅝-inch	390	355	630		Hand	1,000.00		Domestic	
400	E. J. Wilbur	Sec. 14, T. 1 S., R. 14 W.	K 11, 12.	1894	Bored, 6½-inch	315	277	70	50	Electric motor.			Domestic; irrigation.	
401	Wm. Priester	Sec. 12, T. 1 S., R. 14 W.	L-11	1889	Dug, 4 by 4 foot.	335	287	62	60	Wind	80.00	75.00	Domestic	
402	do	do	L 11		do	335	286	55	59	do	75.00	75.00	Irrigation	
403	Mrs. J. B. Skinner	Sec. 18, T. 1 S., R. 13 W.	L 12	1895	Bored, 7-inch	285	277	25	200+	do	30.00	75.00	Domestic; irrigation.	
404	S. L. Jappel	do	L 12	1896	Dug, 3-foot diameter.	290	274	23	200+	do	35.00	100.00	Domestic	
405	Sarah Hill	do	L 12	1891	Dug, 3½ by 3½ foot.	290	273	25	96	do	35.00	100.00	do	
406	Mr. Heard	do	L-12	1896	Dug, 3 by 3 foot.	280	269	16	95	Hand	20.00		do	
407	H. Fastenau	do	L-12	1895	Bored, 7-inch	280	268	40	134	Wind	50.00	125.00	do	
408	G. W. Albright	do	L-12	1896	Dug, 3-foot diameter.	270	265	9	200+	do			do	
409	Wm. Jessup	do	L-12	1900	Dug, 4-foot diameter.	300	292	25	200+	do			do	
410	W. E. Lord	Los Angeles city.	L-12	1901	do	250	192	68	138	do			do	

70	Strong & Dickinson, agents.	do	M-17		do	184	139	194	53	Wind			do	
71	Mrs. A. L. Acker	do	M-17	1900	do	180	136	51	71	do			Domestic; irrigation.	
72	N. C. Oswald	do	M-17	1902	Bored, 10-inch	175	133	230	61	Gas	310.50		Irrigation	
73	do	do	M-17	1902	do	175	133	72	61	do			do	
74	Mr. McNary	do	M-17		Bored, 7-inch	180	132	64	61	Wind			Domestic	
75	Chas. Rohr	do	N-17	1899	do	182	128	66	69	do	200.00		do	
76	Mrs. M. A. Burns	do	N-17		do	186		65	57	do			do	
77	John Redmond	do	N-17	1895	do	186	128	64	41	do	75.00	100.00	do	
78	O. F. Gehre	do	N-17		do	200	135	125	57	do		100.00	Domestic; irrigation.	
79	Daniel Tachet	do	N-17	1900	Dug, 4 by 4 foot	201	Dry.	56		do	300.00	100.00		
80	M. F. Moss	do	N-17		Bored, 7-inch	200	133	110	54	do		100.00	Domestic	
81	J. R. Gager	do	N-17	1901	Bored, 10-inch	201	141	171	58	Gas	*2,000.00		Domestic; irrigation.	
82	do	do	N-17	1900	do	201	141	70		Wind			Not used	
83	D. E. Muttersbaugh	do	N-17	1897	Bored, 7-inch	205	135	114	56	do	250.00	100.00	Domestic	
84	H. C. Simmons	do	M-17	1896	Bored, 6-inch	204	136	101	61	do			do	
85	M. P. Lucas	do	N-17	1895	Bored	208	134	79	57	do			do	
86	W. H. Merrill	do	N-17	1895	Bored, 7-inch	208	134	84		do		100.00	do	
87	Geo. Getchell	do	N-17	1883	do	204	138	84	57	do			do	
88	J. R. Dorsey	do	N-17	1901	Bored, 12-inch	204	138	211	52	Gas			Irrigation	120
89	L. E. Shepherd	do	N-17		Dug	204	Dry.	55						
90	James Oakley	do	N-17	1883	Bored, 7-inch	202	135	68		Wind	100.00	200.00	Not used	
91	J. Pauly	do	N-17		Bored, 8-inch	201	135	76	65	do	100.00	75.00	Domestic	
92	Guy Owen	do	N-17		do	204	Dry.	68						
93	G. J. Reinacker	do	N-17	1901	Bored, 6-inch	198	136	135	56	Wind	200.00	120.00	Domestic; irrigation.	
94	Sam Park	do	N-17	1901	Bored, 7-inch	199	136	130	58	do			Domestic	
95	H. Brewer	do	N-17	1899	Bored, 6-inch	198	146?	107	57	do			do	
96	T. A. Harris	do	N-17	1900	do	196	136	61		do	90.00	100.00	Not used	
97	Dr. M. S. Ertle	do	N-17	1892	Bored, 7-inch	197	134	63					do	
98	Mr. Sherwood	do	N-17		Bored, 6-inch	193			65	Wind		100.00	Domestic	
99	J. C. Scott	do	N-17	1886	Bored, 7-inch	193	136	70	57	do			do	
100	Dr. W. B. Wood	do	N-17		do	200	142	81	59	do		100.00	do	
101	A. L. Whitney	do	N-17	1883	do	201	143	64					Not used	

Wells in Santa Monica quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet)	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
102	E. M. Milsap	Los Angeles city	N-17	1898	Bored, 7-inch	202	142	65					Not used	
103	J. B. Okey	do	N-17	1895	do	190	130	64	61	Wind			Domestic	
104	M. E. Donavan	do	N-17	1901	do	188	138?	74	58	do	$100.00	$100.00	do	
105	W. E. Godsey	do	N-17	1902	do	195	139	74	56	do			do	
106	F. G. Gotts	do	M-17	1893	do	193	137	70	39	Hand			do	
107	W. C. Banks	do	M-17	1896	Bored, 8-inch	194	137	66	64	Wind			do	
108	P. J. Hummel	do	M-17	1885	Bored	184	133	60	59	do			do	
109	Geo. Worth	do	M-17		Bored, 6-inch	183	130	67	60	do			Domestic; stock	
110	A. H. Brocamp	do	M-17	1899	Bored, 9-inch	180	132	190		Gas	380.00	2,500.00	Irrigation	
111	N. Bartol	do	M-17	1881	Bored	180	120	90	63	Wind			Domestic	
112	Fred Espe	do	M-17	1900	Bored, 9-inch	174	134	64	73	Gas	200.00	825.00	Irrigation	
113	Mrs. Laura Carter	do	M-17	1898	Bored, 8-inch	173	132	49	73	Wind			Domestic	
114	John Thill	do	M-17	1895	Bored, 7-inch	175	135	49	61	do	100.00		do	
115	T. Schroeder	do	M-17	1900	do	175	135	52	64	do		100.00	do	
116	Irwin McGinnis	do	M-17	1900	do	177	134	61	67	do	75.00	75.00	do	
117	L. A. Postmaster	do	M-17		do	181	135	50	63	Hand			do	
118	Geo. Zobelein	do	M-17	1903	Bored, 8-inch	186	131	150	62	Gas			Domestic; irrigation.	
119	do	do	M-17	1901	Bored, 10-inch	188	133	190	57	Electric motor			Irrigation	
120	Agricultural Park Dairy.	do	M-17		Bored, 6-inch	185	126	73	62	Wind			Domestic	
121	W. T. Austermell	Sec. 7, T. 2 S., R. 13 W.	M-17	1895	do	176	135	60	58	do			Domestic; stock	
122	Mr. Thorpe	Los Angeles city	M-17		Bored, 8-inch	175	129	68	65	do			do	
123	F. H. Redpath	do	M-17	1903	do	175	129	53	63	do		75.00	Domestic	

124	P. W. Gertz	do	M-17	1891	Bored, 7-inch	174	135	48	86	do	50.00	75.00	do	
125	J. W. Sommerville	do	M-17	1895	do	165	150?	45	69	Wind, gas			Domestic; irrigation.	
126	do	Sec. 7, T. 2 S., R. 14 W.	L-17	1903	do	162	127	98	61	Hand	110.00		Stock	
127	Dr. Pratt	Los Angeles city	M-16			190				Wind			Not used	
129	C. T. Stewart	do	M-16	1895	Bored, 7-inch	188	133	66	64	do		125.00	Domestic	
130	Mrs. E. E. Brown	do	L-16	1896	Bored, 6-inch	182	134		56	do		100.00	do	
131	Mrs. L. S. Elliott	do	L-16	1894	Bored, 7-inch	182	133	96	57	do			do	
132	Mrs. H. P. Andrews	do	L-16	1881	do	177	136	82	63	do		100.00	do	
133	Henry Knauff	do	M-16	1888	Bored, 6-inch	189	146?	100	92	do	135.00	100.00	do	
134	Thos. Bones	do	L-16	1894	Bored, 7-inch	190	146	72	69	do	75.00	325.00	do	
135	D. W. Palmer	do	L-16	1894	do	185	Dry.	40		do	60.00	500.00	Not used	
136	Thos. Lloyd, agent	do	L-16		Bored, 8-inch	185	138	75	64	do			Domestic	
137	Redondo Rwy. Co	do	M-16	1875	Bored, 6-inch	196	135	113	61	do			Engines	
138	Mrs. John Rey	do	L-16		Bored, 8-inch	184	135	61	58	do			Domestic	
139	Agricultural Park	do	L-16, 17		do	177				Gas			Roads	
140	G. W. Guinn	do	L-16	1889	Bored, 7-inch	177	136	112	61	Wind			Domestic	
141	A. Armbruster	Sec. 7, T. 2 S., R. 13 W.	L-17	1895	Bored, 8-inch	166	125	50	63	do		100.00	do	
142	Dr. F. J. Kruel	do	L-17		Bored, 7-inch	160	126	57	65	do			Domestic; stock	
143	Mr. Butler	do	L-17		do	160	125	52	68	do			Domestic	
144	H. A. Goldbach	Los Angeles city	K-15	1893	Bored, 8-inch	213	141	270	54	do			do	
145	Mr. Crippen	do	K-15		Bored, 7-inch	209	140	89	54	do			do	
146	F. W. Marshall	do	K-15	1901	Bored, 10-inch	198	130	235	129	Gas	400.00	1,500.00	do	
147	Otto Wilhelm	Las Cienegas	J, K-15	1902	Bored, 8-inch	210	140	159	81	Wind	300.00	100.00		
148	Mr. Nelson	do	J-15	1898	Bored, 7-inch	220	145	156	54	do		100.00	Domestic	
149	Mrs. F. W. Sonnenburg.	do	J-15	1896	Bored, 6-inch	195	126	99	125	do			do	
150	G. R. Reed	do	J-15	1900	Bored, 18-inch, 50 feet; bored, 12-inch, 32 feet.	180	121	82	74	do	25.00	70.00	do	
151	do	do	J-15	1883	Bored, 7-inch	180	121	90	74	do	125.00	400.00	do	
152	Otto Wilhelm	do	J-15	1901	Bored, 10-inch	195?	130?	200	76	do		100.00	Domestic; stock	
153	Max Byer	do	J-15	1893	Bored	188	120	98	145	do			Domestic	
154	Joseph Burkhart	do	J-15		Bored, 7-inch	174	123	82					Not used	
155	Dr. Nadeau	do	J-15	1887	Bored, 8-inch?	180	64	174	72	Wind			Domestic	

Wells in Santa Monica quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed	Class of well.	Elevation of surface (feet)	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
156	Los Angeles County ..	Las Cienegas	J-15....	1899	Bored, 7-inch...	171	120	96	84	Wind.....	.....	.....	Stock; roads.....	.....
157	Nevada and California Real Estate Co.	.....do.....	J-15....	.....	Bored, 8-inch...	161	121	62	67	.....do.....	.....	.....	Domestic.....	.....
158	O. H. Burbridge.....	Los Angeles city..	K-15....	.....	Bored, 7-inch...	220	136	88	.....	Not used.....	.....	.....	Not used.....	.....
159	M. L. Beardsley.....	.....do.....	K-15....	1899	.....do.....	220	136	235	47	Wind.....	$400.00	$100.00	Domestic.....	.....
160	Ferdinand Holm.....	.....do.....	K-15....	1881	Bored, 8-inch...	210	128	125	47	.....do.....	.....	.....	.....do.....	.....
161	C. F. Stuart.....	.....do.....	K 15....	1884	Bored, 7-inch...	205	137	87	54	.....do.....	90.00	200.00	.....do.....	.....
162	Mrs. F. Gason.....	.....do.....	K 15....	1892	Bored, 9-inch...	200	137	230	54	.....do.....	540.00	560.00	.....do.....	.....
163	Mrs. M. Mitchell.....	.....do.....	K-15....	1887	Bored, 7-inch...	201	137	100	70	.....do.....	.....	.....	.....do.....	.....
164	A. C. Eschrich.....	.....do.....	K 15....	.....	.....do.....	200	137	81	125	.....do.....	.....	.....	.....do.....	.....
165	Miss Kate Bagnall.....	.....do.....	L 15....	1888	Bored.....	206	137	79	101	.....do.....	.....	.....	.....do.....	.....
166	Mr. Orr.....	.....do.....	L-14,15.	.....	Bored, 7-inch...	200	137	75	101	.....do.....	.....	.....	.....do.....	.....
167	John Bruckner.....	.....do.....	L-15....	1888	.....do.....	212	137	90	56	.....do.....	.....	.....	.....do.....	.....
169	Henry C. Jensen.....	.....do.....	K-15....	1887	.....do.....	200	143	82	56	.....do.....	.....	.....	.....do.....	.....
170	.....do.....	.....do.....	K 15....	.....	Dug, 4 by 4 foot, 66 feet; bored, 7-inch, 234 feet.	200	.....	300	.....	.....	.....	.....	Not used.....	.....
171	Leo Jouromsky.....	.....do.....	K-16....	1900	Bored, 7-inch...	163	130	100	39	Wind, gas.....	150.00	.....	Domestic; irrigation.	.....
172	F. A. Ripley.....	.....do.....	K-16....	1900	.....do.....	164	130	90	42	Wind.....	100.00	100.00	Domestic.....	.....
173	A. B. Tomlinsom	.....do.....	K-15....	.....	.....do.....	220	136	149	.....	Electric motor...	.....	350.00	.....do.....	.....
174	P. Pearson.....	.....do.....	L-15....	1892	.....do.....	185	136	67	54	Wind.....	100.00	100.00	.....do.....	.....
175	J. W. Brown.....	.....do.....	L-15....	.....	.....do.....	185	136	67	68	.....do.....	.....	.....	.....do.....	.....
176	R. Radford.....	.....do.....	L-15....	.....	.....do.....	190	136	65	43	.....do.....	.....	.....	.....do.....	.....
177	A. Kosta.....	.....do.....	L-15....	1895	.....do.....	190	135	83	39	.....do.....	.....	100.00	.....do.....	.....

178	T. Widd	do	L-15	1890?	do	192	132	75	44	do	100.00	100.00	do
179	A. J. Franklin	do	L-15	1886	do	189	137	104	54	do	125.00		do
180	Mrs. F. Karpe	do	L-15	1883	do	185	137	63	50	do			do
181	Fred Fritz	do	L-16	1898	do	187	137	100	52	do	95.00	250.00	do
182	Harry Weiss	do	L-16	1900	do	182	137	225	56	Wind, gas	375.00	1,200.00	Domestic; irrigation.
183	Thos. W. Brown, sr.	do	L-16	1898	do	182	134	100	47	Wind	125.00	100.00	Domestic
184	E. A. Hoffman	do	L-16	1892?	do	177	139	75	56	do			do
185	Herbert J. Warner	do	L-16	1887	do	182	134	80	52	do	200.00		do
186	Tony Bright	do	L-16	1894	do	181	139	135	64	do	150.00	[a]1,200.00	do
187	Mrs. C. M. Yale	do	L-16	1898	do	183	139	260	74	do	300.00	150.00	do
188	W. J. Bryant	do	L-16	1898	do	178	138	45	70	do			do
189	R. A. Wiley	do	L-16	1897	do	175	138	55		do	75.00	100.00	do
190	Wm. Rudge	do	L-16	1897	do	169	134	51	58	do	56.00	65.00	do
191	J. W. Dodge	do	L-16	1897	do	168	138	74	63	do	78.00	70.00	do
192	Mrs. E. A. Northrop	do	L-16	1889	do	165	135	47	51	do	50.00	100.00	do
193	G. H. Paine	do	K-16	1897	do	164	135	79	58	do	100.00	100.00	do
194	W. M. March	do	K-16		do	157	131	47	57	do			do
195	H. G. Spottswood	do	L-16	1897	do	175	139	64	59	do	70.00	75.00	do
196	J. E. Mahoney	do	L 16	1894	do	168	134	78	68	do	105.00		do
197	G. W. Hood	do	K-16		do	167	131	73	45	do			do
198	Mrs. Emelie Hertel	do	K-16	1897	do	157	130	60	41	do	60.00	75.00	do
199	C. W. Johnston	do	K-16	1901	do	157	131	48	53	Hand			Not used
200	Lee McConnell	do	K-16	1896	Dug, 3½ by 3½ foot.	150	130	21	81	do	25.00		Domestic
201	A. E. Guinn	do	L-16	1895	Bored, 7-inch	172	130	65	57	Wind			do
202	Dr. Wylie	La Brea	J-11		do	342	274	137	59	do			do
203	F. L. Dodge	do	J-11	1897	do	314	275	52	58	do			do
204	H. Kettle	do	J-11	1900	Dug, 6 by 4 foot.	297	270	37	54	Gas			Domestic; irrigation.
205	N. A. Watson	do	J-11	1895	Bored, 7-inch	313	274	50	56	Wind	50.00	200.00	Domestic
206	F. L. Dodge	do	J-11	1899	Bored	298	270	46	50	do	50.00	250.00	do
207	R. H. Jones	do	J-12	1892	Bored, 7-inch	334	279	160	65	Gas	230.00	450.00	Domestic; irrigation.
209	Mrs. Ida Henkle	do	J-12	1885	Dug, 3 by 3 foot.	280	Dry.	35					

[a] Includes cost of tank house.

Wells in Santa Monica quadrangle—Continued.

Number of well.	Owner.	Location.	Map location	Year completed	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
208	Mrs. Ida Henkle	La Brea	J-12	1899	Dug, 4 by 6 foot, 24 feet; bored, 9-inch, 16 feet.	280	263	40	60	Gas	$100.00	$400.00	Domestic	†7
210	A. C. Haley	do	J-12	1899	Bored, 7-inch	272	250	25	56	Wind	35.00	50.00	do	
211	Mrs. E. G. Eckhart	do	J-12		do	279	229	53	53	do			do	
212	Mr. C. Cole	do	J-11		do	296	272	47	54	do			do	
213	James Warren	Los Felis	L-11	1890	do	420	329	112	54	do			Domestic; irrigation.	
214	do	do	L-11	1895	do	417	329	167	34	Gas			Irrigation	
215	Martin Stoll	do	L-11	1902	Bored	422	329	126	26	Wind			Domestic	
216	Mrs. S. Whitman	do	L-11	1895?	Dug, 3-foot diameter.	401	330	72	24	do			do	
217	Mrs. Anna Baumeister	do	L-11	1895	do	375	318	62	26	Hand			do	
218	C. S. Billman	do	L-11	1903	Bored, 6-inch	370	315	81	38	do	61.00	27.00	do	
219	L. H. Price	do	L-10	1889	Dug, 6-foot diameter.	480	468	22	31	Gas			Domestic; irrigation.	
220	C. J. Griffith	do	L-10	1892	Dug, 3-foot diameter.	480	459	40	31	Hand			Domestic	
221	Mrs. Mary Martin	do	L-10	1890	Bored, 7-inch	550	501	100	26	Wind	130.00	150.00	do	
222	L. Salter	do	L-10	1899	Dug, 4½-foot diameter.	555	510	48	22	Gas	75.00	250.00	Domestic; irrigation.	
223	W. H. Hoegee	do	L-10	1902	Bored, 8-inch	540		370		do			do	
224	G. W. Price	do	L-10	1887	Dug, 6 by 4 foot	500	468	40	41	Wind		100.00	Domestic	
225	Morgan Griffith	do	L-10	1901	Bored, 7-inch	500	450	125	19	Gas	125.00		Domestic; irrigation.	
226	C. F. Fosdick	do	L-10	1897		500	453	72		Wind	100.00	100.00	do	
227	S. A. Leaverton	do	L-10		Bored, 7-inch	510	482	80	26	do	100.00	75.00	Domestic	

228	.....do.....	.....do.....	L-10.....	.....	Dug, 5-foot diameter.	515	478	60	27	.....do.....	100.00	75.00	Irrigation.....	.....
229	.....do.....	.....do.....	L-10.....	1902	Bored, 12-inch..	510	488	254	28	Gas.....	472.00	500.00	.....do.....	†5
230	Wm. Gregory.....	.....do.....	L-10.....	.....	Bored, 16-inch..	510	496	50	27	Wind.....	.....	100.00	.....do.....	.....
231	Ambrose Gregory	.....do.....	L-10.....	1883	Bored, 7-inch...	500	495	300	25	Gas.....	400.00	400.00	.....do.....	.....
232	T. Brotherton.....	.....do.....	L-10.....	1883?	.....do.....	500	493	325	.....	Tunnel.....	.....	.....	.....do.....	.....
233	.....do.....	.....do.....	L-10.....	1883?	.....do.....	500	493	120?	.....	.....do.....	.....	.....	.....do.....	.....
234	Little & Warren.....	.....do.....	L-10.....	.....	.....do.....	490	485	50	.....	.....do.....	.....	.....	.....do.....	.....
235	.....do.....	.....do.....	L-10.....	.....	Bored, 12-inch..	490	485	50	.....	.....do.....	.....	.....	.....do.....	.....
236	.....do.....	.....do.....	L-10.....	.....	Bored, 7-inch...	490	485	.....	.....	.....do.....	.....	.....	.....do.....	.....
237	.....do.....	.....do.....	L-10.....	.....	.....do.....	490	485	.....	.....	.....	.....	.....	.....do.....	.....
238	.....do.....	.....do.....	L-10.....	.....	.....do.....	490	485	.....	.....	.....	.....	.....	.....do.....	.....
239	W. S. Sutton.....	.....do.....	L-10.....	1901	.....do.....	490	485	90	25	Gas.....	.....	.....	.....do.....	.....
240	.....do.....	.....do.....	L-10.....	1901	Bored, 16-inch..	490	485	90	24	.....do.....	.....	.....	.....do.....	.....
241	.....do.....	.....do.....	L-10.....	1896	Bored, 7-inch...	480	479	102	.....	Wind.....	125.00	100.00	Domestic.....	.....
242	J. L. Sledzianoski.....	.....do.....	L-10.....	1895?	.....do.....	450	432	100	31	.....do.....	.....	.....	.....do.....	.....
243	District school.....	.....do.....	L-10.....	.....	.....do.....	520	478	67	.....	.....	.....	.....	.....	.....
244	Mr. Griffith.....	.....do.....	L-10.....	1902	Bored, 12-inch..	480	437	94	28	Hand.....	.....	.....	Domestic.....	.....
245	W. E. Cummings.....	.....do.....	L-10.....	1897	Dug, 3 by 4½ foot	480	451	41	34	Gas, wind.....	.....	.....	Domestic; irrigation.	.....
247	Homer Laughlin.....	.....do.....	K-10.....	1901	Bored, 12-inch..	485	465	400	48	Wind.....	2,000.00	100.00	Irrigation.....	.....
248	T. A. Fry.....	.....do.....	K-10.....	1902	Bored, 5½-inch ..	490	468	60	53	.....do.....	75.00	100.00	Domestic.....	.....
249	Homer Laughlin.....	.....do.....	K-10.....	1902	Bored, 7⅝-inch ..	470	461	60	.....	.....	75.00	.....	Not installed.....	.....
250	E. L. Allen.....	.....do.....	K-10.....	1893	Bored, 7-inch...	440	362	98	.....	Wind.....	.....	.....	Domestic.....	.....
251	W. E. Cummings	.....do.....	L-10.....	1897	.....do.....	500	452	68	36	.....	.....	.....	Not used.....	.....
252	E. L. Allen.....	.....do.....	K-10.....	1901	Bored, 10-inch..	440	283	200+	.....	.....	.....	.....	.....do.....	.....
253	Mr. Griffith.....	.....do.....	L-10.....	1902	Bored, 16-inch..	440	359	1,100	.....	.....	.....	.....	.....do.....	.....
254	.....do.....	.....do.....	L-10.....	1897	Bored, 6-inch...	440	379	121	32	Gas.....	.....	.....	Irrigation.....	.....
255	.....do.....	.....do.....	L-10.....	.....	Bored, 12-inch..	450	446	146	72	.....	.....	.....	Not used.....	.....
256	Peter Tanner.....	.....do.....	L-10,11.	1899	Bored, 7-inch...	430	370	225	72	Gas.....	350.00	600.00	Domestic; irrigation.	.....
257	Geo. H. Stoll.....	.....do.....	L-10,11.	.....	.....do.....	425	343	95	67	Wind.....	.....	.....	.....do.....	.....
258	S. Taylor.....	.....do.....	L-10.....	1890	.....do.....	425	361	102	35	.....do.....	.....	.....	.....do.....	.....
259	I. M. Geib.....	.....do.....	L-10.....	1898	.....do.....	434	342	126	30	Gas.....	200.00	200.00	Irrigation.....	.....
260	J. A. Lewis.....	.....do.....	L-10.....	1901	.....do.....	445	408	76	36	Wind.....	.....	.....	Domestic.....	.....

Wells in Santa Monica quadrangle—Continued.

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261	D. M. Little	Los Feliz	L-10	1893?	Dug, 3-foot diameter.	460	433	24	68	Wind			Domestic; irrigation.	
262	Mrs. H. E. Newton	do	L-10	1883	Bored, 7-inch	440	364	120	32	do	$125.00	$200.00	Domestic	
263	H. A. Bourne	do	L-11	1883	Bored, 8-inch	430	351	88	29	do			do	
264	R. M. Tull	do	K, L 11	1895	Bored, 7-inch	384	304	197	43	Gas	*1,000.00		Domestic; irrigation.	
265	E. A. Eaton	do	K 11	1890	do	390	313	162	44	do	200.00	250.00	do	
266	Mrs. Caroline Lamb	do	K 11	1890	do	405	320	156	54	Wind, gas	200.00		do	
267	Mrs. E. B. Wakeman	do	K 11		do	400	320	140		Gas			do	
268	Lewis Ferry	do	K 11	1895	do	386	306	287	48	do	500.00	600.00	do	†6
269	J. V. Dodds	do	K 11	1893	do	386	288	191	49	Wind	273.00	300.00	Domestic	
270	J. H. Devol	do	K 11	1894	do	382	277	195	52	do	300.00	200.00	do	
271	Reyes Bros	Sec. 11, T. 1 S., R. 14 W.	K 11	1901	do	370	280	249	53	Gas	385.00		Irrigation	†3
272	G. W. Warner	do	K-11		do	354	271	98	60	Wind	120.00	100.00	Domestic	
273	W. C. Fry	do	K-11	1894	do	347	277	275	44	Compressed air	425.00	3,400.00	Irrigation	
274	do	do	K-11	1888	do	351	296	108	33	Wind	175.00	260.00	Domestic	
275	E. C. Hampton	Los Feliz	K-11	1900	do	365	200	237	35	Gas	300.00	900.00	Domestic; irrigation.	†8
276	H. K. Vickroy	do	K-11	1896	do	370	290	291	35	do	480.00		Irrigation; domestic.	†8
277	H. Dwire	do	K-11	1901	do	370	290	300	33	do	900.00		do	
278	do	do	K-11	1901	do	370	290	380			500.00		Not used	
279	Mrs. K. T. McFadden	do	L-11	1900?	Bored, 8-inch	365	310	698	24	Wind	1,200.00	200.00	Domestic	
280	E. F. Bogartis	do	K-11		Bored, 7-inch	360	287	180	40	do	250.00	125.00	do	

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282	A. H. Mann	do	K-11	1900	do	338	276	124	44	do	135.00	150.00	Domestic		
283	U. Remida	do	K-11	1892	Dug, 4-foot diameter.	339	277	64	42	Hand			do		
284	C. Cole	Sec. 11, T. 1 S., R. 14 W.	J-11	1897	Bored, 7-inch	357	285	283	54	Gas	500.00	500.00	Irrigation		
285	Mrs. M. C. Gower	do	J-11	1883	do	350	290	72		Wind, gas			Domestic; irrigation.		
286	Mr. M. Labaig	do	J-11	1885	do	367	281	126		Wind	150.00	100.00	Domestic		
287	Mrs. R. Blondeau	do	J-11	1889	do	358	283	92		do			do		
288	O. S. Adams	La Brea	J-11	1898	do	347	284	200	54	do	250.00	150.00	do		
289	H. D. Wilkerson	Sec. 10, T. 1 S., R. 14 W.	J-11	1898	do	350	268	100		do	100.00		do		
290	A. L. Reves	do	J-11	1899	do	360	280	150	54	Gas	175.00	300.00	Domestic; stock		
291	H. D. Wilkerson	do	J-11	1900	do	365	268	160	77	Wind			Domestic		
292	H. J. Whitley	do	J-11		do	360	260	385	86	Compressed air			Irrigation		
293	Hollywood Cemetery Association.	Sec. 14, T. 1 S., R. 14 W.	J-11	1896	Bored, 10-inch	310	277	85	26	Electric motor			Domestic; irrigation.		
294	W. J. Fay	La Brea	J-11	1903	Bored, 6-inch	300	277	65	33	Wind	65.00	50.00	Domestic		
295	C. W. Walker	do	J-11	1893	Bored, 7-inch	355	265	190	87	Gas	250.00	200.00	Domestic; irrigation.		†2
296	Warren Campbell	do	J-11		do	337	265	93		Wind			Not used		
297	W. Squire	do	J-11	1900	do	348	258	285	84	Gas	407.00	1,000.00	Irrigation		
298	Miss Winsstanley	do	J-11	1897	do	348	258	300	69	Wind			Domestic		
299	Mrs. E. J. Boyle	do	J-11		do	332	261	138	72	do	200.00	150.00	do		
300	T. Davidson	do	I-11		do	350	261	191	71	do	225.00	150.00	do		
301	A. Z. Taft	Sec. 11, T. 1 S., R. 14 W.	K-11	1893	do	398	271	297	57	do	520.00	215.00	do		
302	E. D. Sturdevant	Los Felis	K-10	1902	do	425	300	228	60	Gas	360.00		Domestic; irrigation.		
303	Ashton Fry	do	K-10		Dug, 3-foot diameter.	450	448	9	53	Siphon			Irrigation		
304	do	do	K-10		Dug, 6-foot diameter.	450	443	17	43	do			do		
305	M. Audroda	Sec. 2, T. 1 S., R. 14 W.	K-10	1884	Bored, 7-inch	440	396	60			75.00		Not used		
306	I. W. Lord	do	K-10	1888	Dug, 3 by 3 foot	490	486	17	131	Hand			Domestic		

Wells in Santa Monica quadrangle—Continued.

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307	G. H. Freeman	Sec. 2, T. 1 S., R. 14 W.	K-10	1897	Dug, 3 by 3 foot.	510	500	25	131	Gas			Domestic; irrigation.	
308	F. Godde	Sec. 11, T. 1 S., R. 14 W.	K-10	1891	Bored, 7-inch	425	385	110	61	Wind			Domestic	
309	P. S. Rishel	Sec. 2, T. 1 S., R. 14 W.	K-10	1895	do	470	390	108	67	Gas	$125.00	$500.00	Irrigation	
310	do	do	K-10	1899	do	480	422	70	59	Wind	70.00	80.00	Not used	
311	Frank Fleicher	do	K-10	1902	Dug, 3-foot diameter.	485	447	50	44	do			Domestic	
312	F. Godde	do	K-10	1902	Bored, 10-inch	475	414	96			200.00		Not used	
313	Frank Fleicher	do	K-10	1903	Dug, 3-foot diameter.	500	486	18	61	Not installed				
314	F. Godde	Sec. 11, T. 1 S., R. 14 W.	K-10	1881	Bored, 7-inch	425	383	78	68	Wind	100.00	100.00	Domestic	
315	do	Sec. 2, T. 1 S., R. 14 W.	K-10	1883	Dug, 3 by 3 foot.	424	383	52		Hand	75.00		do	
316	do	Sec. 11, T. 1 S., R. 14 W.	K-10	1899	Bored, 7-inch	420	384	173	64	Wind	250.00	100.00	Irrigation	
317	do	do	K-11	1893	do	414	384	115	65	do	150.00	100.00	do	
318	J. B. Rapp	Sec. 2, T. 1 S., R. 14 W.	J-10	1898	do	450	380	138	68	Gas	190.00	650.00	do	†5
319	do	do	J-10	1878	do	447	380	96	68	Wind	100.00	175.00	Domestic	
320	Presenteion Lopes	do	J-10		do	430	361	95	75	do	100.00	100.00	do	
321	Mr. Twist	Sec. 11, T. 1 S., R. 14 W.	J-11	1886	do	390	364	41	55	do	50.00	75.00	Domestic; irrigation.	
322	D. Ammann	Sec. 2, T. 1 S., R. 14 W.	J-10	1892?	Dug, 3-foot diameter.	490	434	58	86	do	75.00		Domestic	

323	....do....	....do....	J-10....	1896	....do....	485	434	76	86	Gas....	100.00	400.00	Domestic; irrigation.	....
324	Mrs. Florence Laverty	....do....	J-10....	1888	Dug, 4 by 4 foot.	475	444	58	92	Wind....	....	....	Domestic....	....
325	....do....	....do....	J-10....	1902	Bored, 7-inch...	470	410	110	92	....do....	185.00	210.00	....do....	....
326	M. D. McCaslin....	....do....	J-10....	1898	Dug, 3½-foot diameter.	480	422	72	83	....do....	100.00	80.00	....do....	....
327	Arthur Letz....	....do....	J-10....	1895	Dug, 3 by 3 foot.	460	428	61	....	Gas....	....	....	Irrigation....	....
328	....do....	....do....	J-10....	1900	....do....	485	422	105	118	....do....	600.00	....	....do....	....
329	H. E. Voorhies....	....do....	J-10....	1901	....do....	445	398	88	84	....do....	....	....	Not used....	....
330	....do....	....do....	J-10....	....	Dug, 3-foot diameter.	445	398	100	77	....do....	....	....	Irrigation....	....
331	R. J. Northana....	Sec. 10, T. 1 S., R. 14 W.	J-11....	1902	Bored, 10-inch..	380	300	350	52	....do....	500.00	1,000.00	Domestic....	....
332	E. F. Rankin....	La Brea....	J-11....	1894	Bored, 7-inch...	294	269	60	60	Wind....	60.00	100.00	....do....	....
333	Mr. Watts....	....do....	J-11....	....	Dug, 4 by 6 foot.	298	268	36	59	....do....	50.00	125.00	....do....	....
334	Tom Hudson....	Sec. 10, T. 1 S., R. 14 W.	J-11....	1891?	Bored, 7-inch...	378	275	300	91	....do....	....	....	....do....	....
335	....do....	....do....	J-11....	....	....do....	378	275	150	91	....	....	....	Not used....	....
336	Mrs. M. P. Moll....	La Brea....	J-11....	1898	Bored, 10½-inch.	377	266	425	....	Compressed air...	600.00	3,400.00	Irrigation....	....
337	....do....	....do....	I-11....	1898	Bored, 11-inch..	382	259	285	32	Wind....	350.00	200.00	Domestic....	....
338	J. Glass....	Sec. 9, T. 1 S., R. 14 W.	I-11....	....	....	390	....	....	....	Gas....	....	....	Irrigation....	....
339	C. F. Wagner....	....do....	I-11....	1897	Bored, 7-inch...	400	190	468	47	Wind....	600.00	400.00	Domestic....	....
340	Will Sommerville....	....do....	I-11....	1902	Bored, 10-inch..	500	414	112	45	Electric motor...	....	....	Domestic; irrigation.	....
341	Alfred Solano....	....do....	I-10, 11..	1902	....do....	525	420	145	40	....do....	....	....	....do....	....
342	R. B. Lyon....	....do....	I-11....	1894	Bored, 7-inch...	338	238	285	52	Gas....	400.00	600.00	Domestic....	....
343	E. C. Harrington....	....do....	I-11....	1896	Bored, 10-inch..	338	221	300	54	....do....	425.00	400.00	Irrigation....	....
344	T. M. Beaty....	....do....	I-11....	1888	Bored, 7-inch...	340	261	121	54	Wind....	150.00	75.00	Domestic....	....
345	Schryver & Crosby....	Los Felis....	M-11....	1891	Dug, 4 by 4 foot.	412	359	60	101	....do....	....	....	....do....	....
346	H. Schreyder....	....do....	M-11....	1891	Bored, 12-inch..	390	357	400	101	Gas; wind....	....	....	Irrigation....	....
347	Mary A. McHale....	Los Angeles city..	M-11....	1890	Dug, 3 by 3 foot.	345	326	24	180	Hand....	....	....	Domestic....	....
348	Mrs. Mary Martin....	Los Felis....	M-11....	1899	Bored, 12-inch..	405	380	1,100	....	....	....	....	Not used....	....
349	E. A. Knapp....	....do....	L-11....	1885	Dug, 3½-foot diameter.	370	271	106	26	Wind....	....	....	Domestic....	....
350	Mrs. R. H. Chambers....	....do....	L-11....	1901	Bored, 8-inch...	392	324	131	30	....do....	150.00	100.00	....do....	....
351	E. L. Haskins....	....do....	L-11....	1897	Bored, 7-inch...	375	327	75	30	....do....	100.00	100.00	....do....	....

Wells in Santa Monica quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of wells.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
352	Mrs. M. B. Kenyon	Los Felis	L-11	1898	Bored, 7-inch	370	327	107	32	Wind	$150.00	$100.00	Domestic	
353	H. Klages	do	L-11	1886	do	385	321	114	25	do	130.00	125.00	do	
354	Mrs. S. Gunn	Sec. 8, T. 1 S., R. 13 W.	L-11	1893	Dug, 3½ by 3½ foot.	362	304	59	24	do	70.00	125.00	do	
355	Fred Gross	do	M-11	1878	Dug, 4-foot diameter.	360	315	52	119	do		100.00	do	
356	J. H. Moore	Sec. 18, T. 1 S., R. 13 W.	M-11	1903	Bored, 5½-inch	320	292	33	101	Hand	40.00		Not used	
357	N. B. Walker	do	L-11	1903	Bored, 6-inch	325	311	57	33	do	50.00		Domestic	
358	J. Nass	Sec. 8, T. 1 S., R. 13 W.	L-11	1895	Dug, 3-foot diameter.	330	312	23	29	Wind			do	
359	R. Ybarra	Sec. 18, T. 1 S., R. 13 W.	L-11	1901	Dug, 4 by 4 foot.	325	312	18	45	Hand			do	
360	Nickolas Priester	Sec. 12, T. 1 S., R. 14 W.	L-11	1881	Dug	328	310	23	58	Wind	30.00	75.00	Domestic; irrigation.	
361	D. Sullivan	Sec. 13, T. 1 S., R. 14 W.	L-12	1894	Dug, 4 by 4 foot.	320	291	35	58	do			Domestic	
362	C. O. Randall	Sec. 7, T. 1 S., R. 13 W.	L-11	1898	Dug, 3½-foot diameter.	335	315	25	23	do	30.00	100.00	do	
363	John Bartell	Sec. 12, T. 1 S., R. 14 W.	L-11	1901	Bored, 12-inch	337	309	65	33	do	75.00		do	
364	May B. Bright	Los Felis	L-11		Bored, 7-inch	348	314	50	78	do	50.00	150.00	do	
365	Miss Wheeler and Mrs. Skinner.	do	L-11		Dug, 2½-foot diameter.	350	314	41	200+	do	50.00	150.00	do	
366	Nickolas Priester	Sec. 12, T. 1 S., R. 14 W.	L-11	1900	Dug, 4½ by 4½ foot.	347	315	41	101	do	50.00	50.00	do	
367	Mrs. K. Pates	Los Felis	L-11	1893	Dug, 6 by 6 foot.	348	313	65	53	do	75.00	100.00	do	
368	Mrs. Fellows	do	L-11		Bored, 7-inch	380	319	63		do	75.00	100.00	do	

369	C. Boehucke	Sec. 18, T. 1 S., R. 13 W.	L-11	1895	Dug, 3-foot diameter.	320	Dry.	24						
370	Wm. Lehnhardt	do	L-12		Dug, 6-foot diameter.	297	281	25	45	Wind	35.00	100.00	Domestic	
371	E. F. Henderson	do	L-12	1888	Dug, 3-foot diameter.	285	269	25	66	Hand			Domestic; stock	
372	Mr. Atkinson	Sec. 13, T. 1 S., R. 14 W.	L-12		Dug, 4 by 4 foot.	285	265	30	92	Wind	35.00	65.00	Domestic	
373	Mrs. M. J. McConnell	do	L-12	1890	Dug, 3-foot diameter.	285	267	18	30	do	50.00	75.00	do	
374	E. T. Yerxa	do	L-12		Dug, 4-foot diameter.	285	265	30	40	do	50.00	100.00	do	
375	do	do	L-12		Dug, 4 by 4 foot.	280	265	30	41	Electric motor	45.00	200.00	Irrigation	
376	F. P. Chaffee	do	L-12	1900	do	301	270	40	42	Wind	50.00	175.00	Domestic	
377	Chas. Hert	do	L-12	1901	Dug, 4-foot diameter.	300	264	56	52	do	75.00	150.00	Domestic; irrigation.	
378	A. L. Hodges	do	K-12	1895	Dug, 3½-foot diameter.	300	264	45	31	do	50.00	75.00	Domestic	
379	Mrs. W. Newman	do	L-12	1885	Dug, 4 by 4 foot.	305	281	26	37	do	35.00	75.00	do	
380	F. P. Chaffee	do	L-12	1902	Dug, 3½ by 3½ foot.	320	289	50	40	do	65.00	125.00	do	
381	E. Hahn	do	L-11	1895	Dug, 5 by 5 foot.	325	284	45	47	do	60.00	75.00	do	
382	Wm. Priester	Sec. 12, T. 1 S., R. 14 W.	L-11	1899	Bored, 16-inch	325	285	47	125	do	75.00	100.00	do	
383	Mrs. Basley	do	L-11	1896	Dug, 3½ by 3½ foot.	330	285	57	123	do	75.00	100.00	do	
384	C. Jenkins	do	L-11	1898	Dug, 3-foot diameter.	330	276	58	76	do	75.00	80.00	do	
385	do	do	L-11	1902	Dug, 4-foot diameter.	330	277	68	53	do	100.00	75.00	Domestic; irrigation.	
386	John Rehfuss	Sec. 13, T. 1 S., R. 14 W.	K-11	1899	do	325	277	60	58	do	75.00	65.00	Domestic	
387	Geo. P. Swan	do	K-11	1896	Bored, 7-inch	320	283	76	37	do	100.00	100.00	do	
388	German Church	do	K-11	1897	do	320	283	57	39	do	75.00	100.00	Domestic; irrigation.	
389	Philip Schneider	Sec. 12, T. 1 S., R. 14 W.	K-11	1896?	Dug, 4-foot diameter.	325	279	58	33	do	75.00	150.00	Domestic	
390	Mr. Young	do	K-11	1898?	Bored, 7-inch	325	276	60	46	do	75.00	100.00	do	
391	L. F. Bowker	do	K-11	1896	Dug, 4 by 4 foot.	322	286	45	36	do	55.00	75.00	do	
392	J. Stansfield	do	K-11	1903	Bored, 6-inch	325	280	62	29	Hand	46.50		do	

Wells in Santa Monica quadrangle—Continued.

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393	S. C. Stevenson	Sec. 12, T. 1 S., R. 14 W.	K, L-11	1903	Bored, 6-inch	320	280	61	20	Hand	$45.75		Domestic	
394	Mr. Cornell	do	K, L-11	1903	do	340	286	60	41		45.00		Not installed	
395	R. C. Kaestner	Sec. 13, T. 1 S., R. 14 W.	K-12	1898	Dug, 4 by 4 foot.	310	270	50	40	Wind	75.00	$100.00	Domestic	
396	Clara Lawrence	do	K-12		Bored, 7-inch	315	286	48	59	do	50.00	75.00	do	
397	Fred F. Wheeler	Los Angeles city	M-13	1895	Bored, 7½-inch	305	303	500	150+	do	1,200.00	125.00	Irrigation	
398	L. A. P. Rwy. Co	do	L-13	1903	Bored, 9½-inch	250		300+						
399	A. H. Hedley	do	M-12	1902	Bored, 7½-inch	390	355	630		Hand	1,000.00		Domestic	
400	E. J. Wilbur	Sec. 14, T. 1 S., R. 14 W.	K-11, 12	1894	Bored, 6½-inch	315	277	70	50	Electric motor			Domestic; irrigation.	
401	Wm. Priester	Sec. 12, T. 1 S., R. 14 W.	L-11	1889	Dug, 4 by 4 foot.	335	287	62	60	Wind	80.00	75.00	Domestic	
402	do	do	L-11		do	335	286	55	59	do	75.00	75.00	Irrigation	
403	Mrs. J. B. Skinner	Sec. 18, T. 1 S., R. 13 W.	L-12	1895	Bored, 7-inch	285	277	25	200+	do	30.00	75.00	Domestic; irrigation.	
404	S. J. Jappel	do	L-12	1896	Dug, 3-foot diameter.	290	274	23	200+	do	35.00	100.00	Domestic	
405	Sarah Hill	do	L-12	1891	Dug, 3½ by 3½ foot.	290	273	25	96	do	35.00	100.00	do	
406	Mr. Heard	do	L-12	1896	Dug, 3 by 3 foot.	280	269	16	95	Hand	20.00		do	
407	H. Fastenau	do	L-12	1895	Bored, 7-inch	280	268	40	134	Wind	50.00	125.00	do	
408	G. W. Albright	do	L-12	1896	Dug, 3-foot diameter.	270	265	9	200+	do			do	
409	Wm. Jessup	do	L-12	1900	Dug, 4-foot diameter.	300	202	25	200+	do			do	
410	W. E. Lord	Los Angeles city	L-12	1901	do	250	192	68	138	do			do	

411	John W. Mitchell	Sec. 24, T. 1 S., R. 14 W.	L-13	1901	Bored, 9½-inch	255		450					Not used		
412	D. W. Edwards	Los Angeles city	L-13	1900	Bored, 12-inch	260	260	1,750		Artesian			Baths	15	
413	Irey Barrow	Sec. 13, T. 1 S., R. 14 W.	L-12	1883	Dug, 2½-foot diameter.	280	278	70	15	Hand			Domestic		
414	do	do	L-12	1883	Dug 4 by 4 foot.	270	269	5	35	do			do		
415	do	do	L-12	1873	Dug, 3½-foot diameter.	275	262	30	103	do	50.00		Irrigation		
416	Hulda Brawn	do	L-12	1899?	Dug, 4 by 4 foot.	275	248	30	168	Wind	45.00	75.00	Domestic		
417	E. D. Music	do	L-12	1897?	do	300	253	60	125	do	75.00	85.00	do		
418	T. J. Read	Sec. 14, T. 1 S., R. 14 W.	K-12	1894	Bored, 7-inch	305	267	70	37	do	85.00	150.00	do		
419	A. Birklein	do	K-12	1895	do	305	268	75	45	Gas	100.00	400.00	Domestic; irrigation.		
420	do	do	K-12	1902	do	305	268	70	47	Wind	85.00	196.00	Irrigation		
421	L. W. Myers	do	K-12		do	300	264	90	39	Gas	100.00	400.00	Domestic; irrigation.		
422	B. Witherell	Sec. 13, T. 1 S., R. 14 W.	K-12	1902	do	300	270	80		Wind	80.00	85.00			
423	B. Duin	do	K-12	1873	Dug, 4-foot diameter.	300	268	40	42	do			Domestic		
424	do	do	K-12	1900	Bored, 10-inch	300	300	540			2,000.00		Not used		
425	W. A. Gooding	Sec. 14, T. 1 S., R. 14 W.	K-12	1891	Bored, 7-inch	295	260	43	39	Wind	50.00	75.00	Domestic		
426	H. Schulthis	Sec. 13, T. 1 S., R. 14 W.	K-12	1902	do	290	270	115	84	Gas	125.00	350.00	Domestic; irrigation.		
427	do	do	K-12	1893?	do	290	267	70		Wind	75.00	75.00	Irrigation		
428	Fred Schmidt	Sec. 24, T. 1 S., R. 14 W.	L-13	1901	Bored, 7½-inch	275	245	525			2,000.00				
429	H. B. Kelsey	do	L-13	1900	Bored, 6-inch	270		300			500.00				
430	do	do	L-13	1875	Dug, 3-foot diameter.	275	232	53	80	Hand			Domestic		
431	Mrs. M. L. Frary	Sec. 13, T. 1 S., R. 14 W.	K-12	1901	Bored, 5½-inch	280	280	296			500.00		Not used		
432	V. A. Pernot estate	Sec. 14, T. 1 S., R. 14 W.	K-11	1897	Bored, 7-inch	310	273	85	52	Wind	100.00	125.00	Domestic		
433	Robert Lewis	do	K-11	1901	Bored, 10-inch	310	310	1,284	200+	Artesian			Irrigation		
434	Mrs. Eliza Wade	do	K-12	1888	Dug, 3 by 3 foot.	295	257	45	59	Wind	50.00	100.00	Domestic		
435	Stoll estate	do	K-12	1898	Bored, 7-inch	288	257	65	37	do	75.00	100.00	do		
436	L. Huber	do	K-12	1893	Dug, 3 by 4 foot	275	253	25	46	do			do		

Wells in Santa Monica quadrangle—Continued.

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437	W. P. Moon & Co	Sec. 24, T. 1 S., R. 14 W.	K 13	1901	Bored, 7⅞-inch	245	245	625	114	Artesian	$1,500.00			
438	Carl Hoechlin	Sec. 14, T. 1 S., R. 14 W.	K-12	1886	Dug, 2½ by 2½ foot.	275	252	25	60	Wind	50.00	$100.00	Domestic	
439	do	do	K-12	1902	Bored, 7-inch	275	273	500			1,000.00		Not used	
440	J. Bailey	do	J, K-12	1902	Dug, 3-foot diameter.	275	247	37	47	Wind	50.00	125.00	Domestic	
441	S. A. Crumrine	do	K 11		Bored, 7-inch	310	266	50	68	do	75.00	100.00	do	
442	do	do	K-11		do	310	269	44	69		65.00		Not used	
443	Mr. I. A. Weld	do	K-12	1868	Dug, 4 by 4 foot.	280	264	23	72	Hand			Domestic	
444	do	do	K-12	1886	Bored, 8-inch	285	285	825	171	Artesian			Irrigation	(a)
445	Mr. Gus Runebeck	Sec. 13, T. 1 S., R. 14 W.	K-12		Dug, 3 by 4 foot.	283	265	25	134	Wind	35.00	75.00	Domestic; stock	
446	Mrs. Mary Hall	do	K-12		Dug, 3½ by 3½ foot.	291	264	35	92	Hand			Domestic	
447	Mr. Merryfield	Sec. 24, T. 1 S., R. 14 W.	K-12, 13		Dug, 3 by 3 foot.	260	227	46	133	Wind	50.00	65.00	Stock	
448	Mrs. S. Shepherd	do	K-12		Dug, 4 by 4 foot.	260	229	42	43	do			Domestic	
449	J. M. Southworth	do	K-13	1902	Bored, 7-inch	250	210	80		do	100.00	100.00	do	
450	do	do	K-13	1901	Bored	235	235	500					Not used	
451	Ed. Glass	do	L-13	1903	Bored, 7-inch	270	216	200	116	Wind	200.00	75.00	Domestic	
452	Ed. Gird	do	L-13	1891	do	260	194	83	108	do	100.00	75.00	do	
453	do	do	L-13		do	260	194	75	98	do	90.00	75.00	Stock; irrigation	
454	G. L. Schmidt	Los Angeles city	L-13		Dug, 3 by 6 foot.	195	187	12	133	do	25.00	75.00	Stock	
455	Edward Schmidt	Sec. 24, T. 1 S., R. 14 W.	L-13	1875	Dug, 4 by 4 foot.	205	202	15	200+	do	25.00	75.00	do	

458	[illegible]	14 W.	[illegible]	[illegible]	[illegible]										
459	*Geo. Simmons*	*do*	K-13	1900	Bored, 9½-inch	238				Artesian					10
460	do	do	K-13	1901	do	237									
461	Will Thornton	do	J-13	1901	Hydraulic, 4-inch.	238		834							
462	F. & J. Pellissier	Los Angeles city	K-14	1902	Bored, 10-inch	200	177	90	140	Wind			Domestic; stock		
463	do	do	K-14	1895	Dug, 6-foot diameter.	189	177	40	190	do			Stock		
464	Mr. Pellissier	do	K-14		Dug, 6 by 6 foot	202	186	25	172	do			Domestic		
465	Mr. O. W. Lewis	do	K-14		Dug, 4 by 4 foot	185	160	26	170		50.00		Not used		
466	John Sotterwhite	do	K-14	1897	Bored	190	155	50	160	Wind	60.00	100.00	Irrigation		
467	Mr. Prudens	do	K-14	1900	Bored, 7-inch	200	160	50	150	do	60.00	100.00	Domestic		
468	M. C. Teatsworth	do	K-14	1896	do	205	171	50	177	do	60.00	100.00	Irrigation		
469	Robert Pompey	do	L-14	1899	do	200	Dry.	37			50.00	75.00			
470	Orin Capito	do	L-14, 15		do	230	147	100	97	Wind	125.00	75.00	Domestic		
471	Mary Anderson	do	L-14	1883	do	230	156	85	63	do	100.00	100.00	do		
472	L. Longstrom	do	L-14		Dug, 3½ by 3½ foot.	240	184	60		do	75.00	75.00	Not used		
473	C. E. Bridges	Sec. 14, T. 1 S., R. 14 W.	J-12	1883	Dug, 4 by 4 foot	264	243	30	72	do	50.00	75.00	Domestic; irrigation.		
474	J. Zazoux	do	K-12	1878	Dug	255	251	10	64	do			Domestic		
475	Mr. Cole	La Brea	J-12		Bored, 12-inch	275	275		200+	Artesian					(a)
481	F. P. Shoemaker	do	I-13	1885	Bored, 7-inch	215	199	82	69	Wind			Domestic		
482	Mrs. Ida Hancock	do	I-13		Dug, 2 by 3 foot	200	186	20	76	do			Domestic; stock		
483	A. F. Gilmore	do	H-13	1876	Dug, 15 by 20 foot.	205	203	14	81	do		75.00	do		
484	Mrs. Ida Hancock	do	I-13	1897	Dug, 4 by 4 foot	225	189	38	80	do		75.00	do		
485	do	do	I-12	1883	Dug, 3 by 3 foot	230	207	25		do	30.00		do		
486	do	do	I-12	1891	do	245	209	38	66	do	50.00		do		
487	J. S. Thrasher	do	I-12		do	287	251	36	65	Hand	50.00		Domestic		
488	E. L. Baker	do	I-11		Bored, 10-inch	321	250	259	63	Wind	400.00	100.00	do		
489	Geo. Lingo	do	I-11	1901	Bored, 7-inch	315	259	100	69	Hand	100.00	25.00	do		
490	Price & Whitmore	do	I-11		do	305	255	120	62	Gas	150.00		Irrigation; domestic.		
491	R. O. Robinson	do	I, J-11	1887	do	305	265	100	77	Wind	125.00	75.00	Domestic		

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Wells in Santa Monica quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
492	Mrs. M. J. Rogers	Las Cienegas	I-14	1878	Bored, 18-inch	175	160	25	123	Hand			Domestic	
493	do	do	I-14	1878	Dug, 3 by 3 foot	170	165	10	125	do			Stock	
494	L. P. Mansfield	do	I-13		Dug, 4 by 4 foot	150	138	20	89	do			Domestic	
496	Mr. R. E. Hulburt	do	I-13	1885	Bored, 7-inch	180	162	84	58	Wind	$100.00	$75.00	do	
497	Mrs. Ida Hancock	La Brea	J-13		Dug, 3 by 3 foot	170	163	15	78	Hand			Domestic; stock	
498	Mrs. L. Smith	Las Cienegas	J-14	1902	Dug, 3 by 4 foot	148	139	12	96	do			Domestic	
499	Susan Hardy	do	K-14		Dug, 3 by 3 foot	150	139	15	200+	Wind		50.00	Stock; domestic	
500	Lucy Vanderwort	do	J-14	1891	Bored, 7-inch	186	130	85	96	do			Domestic	
501	do	do	J-14		do	187	130	70	86	do		75.00	do	
502	Wm. Auderes	do	J-14	1886	do	168	125	140	86	do	160.00	100.00	do	
503	E. Jennison	do	J-14	1901	Dug, 5 by 5 foot	186	130	65	80	do			Factory	
504	C. W. Brashear	do	I-14	1902	Dug, 3 by 3 foot	210	197	20	107	do	35.00	125.00	Irrigation	
505	do	do	I-14		Dug, 18-inch	216	197	27	101	do	40.00	100.00	Domestic	
507	Mrs. Mary Masselin	do	I-13	1883	Dug, 6 by 6 foot	209	197	30	86	do	50.00	100.00	do	
508	Mrs. Ida Hancock	La Brea	I-13	1902	Dug, 4-foot diameter	200	195	10	101	do	25.00	100.00	do	
509	do	do	I-13	1880	Dug, 6 by 6 foot	199	195	9	103	do	25.00	75.00	Domestic; stock	
512	H. O. Pickrel	do	H-14	1899	Bored, 10-inch	125	88	200	74	do	400.00	100.00	Domestic	
513	C. Grewe	do	G-14	1883	Dug, 4 by 4 foot	110	96	15	84	do	25.00	75.00	do	
514	J. H. Whitworth	do	G-14	1887	Bored, 6-inch	125	114	61	80	do	75.00	75.00	do	
515	do	do	G-13	1898	Bored, 8-inch	140	129	150	68	Gas	200.00	600.00	Irrigation	60
516	do	do	G-13	1898	Bored, 9-inch	139	129	150	68	do	200.00		do	
517	do	do	G-13	1898	Bored, 6 inch	138	129	257	68		300.00		Not used	
518	Wm. Niles	do	G-13		Bored, 14-inch	170	164	150	103	Wind	200.00	65.00	Domestic	

519	.....do.....	.....do.....	G-12....	.....	.....do.....	180	180	160	72	Artesian.....	.....	.....	Irrigation.....	†3
520	Rommel Oil Co.....	Rodeo de Las Aguas.	H-14....	.....	Dug, 4 by 4 foot.	151	123	48	98	Gas.....	.....	.....	Oil wells.....	.....
521	J. H. Whitworth.....	.....do.....	H-14....	1883	Bored, 7-inch...	145	116	90	84	Wind.....	100.00	75.00	Domestic.....	.....
522	.....do.....	.....do.....	H-14....	1902	.....do.....	150	116	.....	56	.....	.....	.....	Not used.....	.....
525	W. H. Mansfield.....	Las Clenegas.....	H-14....	1902	Dug, 4 by 8 foot, 22 feet; bored, 9¼-inch, 168 feet.	120	118	190	85	Gas.....	350.00	450.00	Irrigation.....	35
526	.....do.....	.....do.....	H-14....	1880?	Bored, 7-inch...	155	111	61	98	Wind.....	75.00	100.00	Domestic.....	.....
527	Mrs. Tenoni	.....do.....	H-14....	.....	Dug, 4 by 4 foot.	120	119	12	.....	.....do.....	25.00	75.00	Stock.....	.....
528	Manuel Slier (tenant).....	.....do.....	H-14....	.....	.....do.....	140	132	12	145	Hand.....	100.00	.....	Domestic.....	.....
529	Mrs. T. Coyle.....	.....do.....	H, I-14..	.....	.....do.....	155	140	20	160	.....do.....	.....	.....	.....do.....	.....
530	Wm. Greve.....	.....do.....	I-14	1890	Bored, 7-inch...	182	135	60	70	Wind.....	75.00	75.00	.....do.....	.....
531	Mrs. Mary Masselin.....	.....do.....	I-14	.....	Dug, 18-inch....	210	182	30	125	Hand.....	50.00	.....	Stock.....	.....
532	L. A. Clark.....	.....do.....	I-14	1895	Dug, 4 by 4 foot.	163	135	31	58	Wind.....	.....	.....	Domestic.....	.....
533	Julius Hauser.....	.....do.....	I-14	1900	Bored, 12-inch..	140	140	425	36	Artesian.....	.....	.....	Manufacturing ...	5
534	.....do.....	.....do.....	H-15....	1889	.....	150	120	150	.....	.....	.....	.....	.....	.....
535	.....do.....	.....do.....	H-15....	1895	Bored, 6-inch...	130	130	388	36	Artesian.....	.....	.....	Duck pond.....	3
536	A. D. Keating.....	.....do.....	I-14	.....	Bored, 12-inch..	155	152	.....	134	Hand.....	.....	.....	Stock.....	.....
537	Rosedale Cemetery Association.	.....do.....	I-14	.....	Dug, 4 by 4 foot.	150	116	40	96	Wind.....	.....	75.00	Domestic.....	.....
538	.....do.....	.....do.....	I-14	.....	Bored, 12-inch..	140	127	870	76	.....	.....	.....	Not used.....	.....
539	.....do.....	.....do.....	I-14	.....	.....do.....	140	127	162	76	.....	.....	.....	.....do.....	.....
540	A. D. Keating.....	.....do.....	I-14	1903	Dug, 3-foot diameter.	120	116	6	84	Hand.....	.....	.....	Domestic.....	.....
541	Cienega school district.....	.....do.....	I-14	1893?	Dug, 3 by 3 foot.	140	127	17	86	Wind.....	25.00	75.00	.....do.....	.....
542	L. A. P. Rwy. Co.....	.....do.....	J-14	1903	Bored, 12-inch..	135	112	100	76	Electric motor....	200.00	.....	Engines.....	.....
543	Mrs. A. H. Chalmers.....	.....do.....	J-14	1902	Bored.....	152	110	183	70	Wind.....	250.00	150.00	Domestic.....	.....
544	P. F. Wise.....	.....do.....	J-14	1895	Bored, 7-inch...	155	109	83	79	.....do.....	100.00	100.00	.....do.....	.....
545	A. D. Keating.....	.....do.....	I-15	.....	Bored, 12-inch..	145	133	.....	160	.....do.....	.....	250.00	Domestic; stock..	.....
546	Julius Hauser.....	.....do.....	H-15....	.....	Dug, 4 by 4 foot.	135	116	25	200+	.....do.....	.....	.....	Domestic.....	.....
547	Mrs Ida Hancock.....	La Brea.....	I-12....	.....	.....do.....	240	218	23	.....	Hand.....	35.00	.....	Stock.....	.....
548	S. R. McClellan.....	.....do.....	I-11	.....	Bored, 7-inch...	350	273	150?	60	Wind.....	100.00	.....	Domestic; irrigation.	.....
549	S. W. Price.....	.....do.....	I-11	1897	.....do.....	345	271	160	66	Gas.....	200.00	75.00	Domestic.....	.....
550	Loren Allen.....	.....do.....	I-11	1893	.....do.....	343	271	105	29	Wind.....	125.00	100.00	Domestic; irrigation.	.....

Wells in Santa Monica quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
551	Mrs. A. T. De Steiger..	La Brea.....	I-11		Bored, 7-inch...	352	272	200	64	Wind, gas.....	.....	.....	Domestic; irrigation.	.....
574	Ballona Water Co.....	Las Cienegas.....	H-15.....	.....	Bored, 6-inch...	98	98	150	85	Artesian.....	.....	.....	Irrigation.....	Small
575	.....do.....	.....do.....	H-15.....	1902	Bored, 12-inch..	98	98	464	101	.....do.....	.....	.....	.....do.....	†12
576	.....do.....	.....do.....	H-15.....	1903	.....do.....	97	97	520	103	.....do.....	.....	.....	.....do.....	7
577	F. Rimpan.....	.....do.....	I-16	1903?	.....do.....	100	97	125	52	Not installed.....	.....	.....	.....	.....
57.	A. D. Keating.....	.....do.....	I-15	.....	Bored, 8-inch...	100	100	1,200	47	Artesian.....	.....	.....	Irrigation.....	3
579	Mr. Bull.....	.....do.....	H-15.....	.....	Bored, 7-inch...	97	97	.....	52	.....do.....	.....	.....	Domestic.....	1.6
580	.....do.....	.....do.....	H-15.....	.....	.....do.....	97	97	.....	52	.....do.....	.....	.....	Irrigation.....	.....
581	.....do.....	.....do.....	H-15.....	.....	.....do.....	97	97	.....	52	.....do.....	.....	.....	.....	†2
582	A. D. Keating.....	.....do.....	H 15.....	.....	Dug, 3 by 3 foot.	89	84	8	140	Hand.....	.....	.....	Domestic; stock..	.....
583	Dora Marxen.....	.....do.....	H-15.....	1900?	Dug, 4 by 4 foot.	89	83	14	200+	.....do.....	.....	.....	Domestic.....	.....
584	.....do.....	.....do.....	H-15.....	1875?	Bored, 7-inch...	87	85	35	200+	.....	.....	.....	Not used.....	.....
585	Ballona Water Co.....	.....do.....	H-15.....	1900	Bored, 12-inch..	97	97	425	50	Artesian.....	.....	.....	Irrigation.....	†14
586	Los Angeles County...	.....do.....	H-15.....	.....	Bored, 6-inch...	97	93	10	50	Wind.....	$20.00	$125.00	Roads.....	.....
587	L. Sentons.....	Los Bueyes.....	H-15.....	1888?	Dug, 4 by 4 foot	87	84	14	54	.....do.....	.....	75.00	Domestic; stock..	.....
588	.....do.....	.....do.....	H-15.....	1890?	.....do.....	87	83	20	.....	Steam.....	.....	.....	Factory.....	.....
589	Artesian Water Co....	Paso de la Tijera..	H-16.....	1902	.....do.....	98	89	16	73	Wind.....	.....	.....	Domestic.....	.....
590	.....do.....	.....do.....	H-16.....	.....	Dug, 3 by 4 foot.	100	96	12	129	Hand.....	.....	.....	Domestic; stock..	.....
591	Marius Monea.....	Los Bueyes.....	G-17.....	1901	Bored, 8-inch...	190	155	225	77	Wind.....	300.00	100.00	Domestic.....	.....
592	.....do.....	.....do.....	G-17.....	.....	Dug, 4 by 4 foot.	190	155	38	77	Hand.....	.....	.....	.....do.....	.....
593	W. B. Finch.....	.....do.....	G-16.....	.....	Dug, 3 by 3 foot.	148	128	30	84	.....do.....	.....	.....	.....do.....	.....
594	Lee Long.....	.....do.....	G-16.....	.....	.....do.....	175	171	8	62	.....do.....	.....	.....	Domestic; irrigation.	.....
595	B. Casserini.....	.....do.....	G-16.....	1900	Dug, 4 by 4 foot.	100	86	20	38	Wind.....	.....	.....	.....	.....

596	J. Vilelle	do	G-16	1901	do	96	68	35	72	Hand	50.00		Domestic	
597	A. D. Keating	do	G-16	1898	Dug, 3 by 3 foot	88	58	35	61	Wind	50.00	75.00	do	
598	do	La Ballona	G-16		do	100	70	35	61	do	50.00	75.00	do	
599	Mrs. C. O. Higuera	Los Bueyes	F-16	1897	do	102	66	40	81	do	60.00	100.00	do	
600	E. R. Higuera	do	F-16	1901	Dug	102	66	40						
601	B. J. Higuera	do	F-16	1892	Dug, 3 by 3 foot	103	65	50	74	Wind	65.00	100.00	Domestic	
602	Mrs. Eliza Hoke	do	F-16	1903	Bored, 10-inch	103	68	70	79	do	115.50		do	
603	Mr. Bottier	do	G-16		Dug, 3 by 3 foot	104	85	23	43	Hand			do	
604	Mrs. R. Krueger	do	G-16	1901	do	104	86	24	118	Wind	30.00	100.00	do	
605	L. V. Higuera	do	G-16	1899	Dug, 3 by 4 foot	104	84	29	85	do			do	
606	Los Angeles County	do	G-16	1901	Bored, 7-inch	102	90	47	77	do			Roads; stock	
607	L. V. Higuera	do	G-16	1887	Dug, 4 by 4 foot	104	88	36	79	do	50.00	100.00	Domestic	
608	A. D. Keating	do	G-16	1899	do	94	92	10	57	Hand	25.00		do	
609	C. E. Hodgson	Sec. 9, T. 1 S., R. 14 W	I-11	1894	Bored, 7-inch	320	260	284	56	Gas, wind	494.00	500.00	Irrigation; domestic	
610	S. Moran	do	I-11	1894	Dug, 2½ by 2½ foot	300	Dry.	60						
611	A. K. Rawson	do	I-11	1902	Bored, 7-inch	300	213	208	50	Gas	283.00	200.00	Irrigation	
612	Mr. Plummer	do	I-11		do	285	207	80	58	Wind			Domestic	
613	W. J. Rooks	do	I-11	1901	Dug, 3½-foot diameter	270	225	60	56	do	100.00	75.00	do	
614	Alfred Watts	do	H-11		Bored, 10-inch	300	199	300?		Gas?			Irrigation	
615	K. C. Wagonbach	Sec. 16, T. 1 S., R. 14 W.	H-11		Dug, 4 by 4 foot	290	210	85	54	Wind			Domestic	
616	School district	Sec. 17, T. 1 S., R. 14 W.	H-11		Bored, 7-inch	295	208	102	53	do	120.00	125.00	do	
617	I. N. Wilson	Sec. 9, T. 1 S., R. 14 W	H-11	1895	do	350	235	385	49	Electric motor	750.00	350.00	Irrigation	†9
618	H. C. Bradley	do	I-11		do	400	230	250		Gas			do	
619	I. N. Large	do	H-11	1900	Dug, 4 by 4 foot	475	430	95	45	do			Domestic; irrigation	†4
620	W. J. Bliesner	do	H-11	1902	Bored, 7-inch	475	435	290	56	do	*1,800.00		do	
621	J. Miller	do	H-11	1897	Dug, 4 by 4 foot	500		40		do	75.00	200.00	Domestic	
622	Wm. Wagonbach	Sec. 17, T. 1 S., R. 14 W.	H-11	1897	do	290	210	84	54	Wind	100.00	125.00	do	
623	Mrs. A. Hay	Sec. 8, T. 1 S., R. 14 W.	H-11	1883	Bored, 7-inch	320	205	120	62	do			Domestic; irrigation	

Wells in Santa Monica quadrangle—Continued.

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671	Jean Seutons	Los Bueyes	G-15		Bored, 7-inch	140	73	77	73	Wind	$100.00	$65.00	Domestic	
672	Jean Bourbel	do	F-15		Dug, 3 by 3 foot	140	75	70	68	do	65.00		do	
673	A. D. Keating	do	F-15		do	140	75	70	73	do	75.00		Stock	
674	D. M. Vejar	do	G-16	1900	Bored, 7-inch	109	89	28	103	do	50.00	75.00	Domestic	
675	L. Seutons	do	F-16	1885?	do	138	90	52	160	do	65.00	125.00	Irrigation	
676	Joe Lamb	do	F-15	1885	do	170	76	109	67	do	125.00	100.00	Domestic	
677	Byron Clark	do	F-16	1889	Dug, 4 by 4 foot	145	95	55		do		100.00	Domestic; irrigation	
678	Garnsey Investment Co.	do	F-16	1896	Dug, 4 by 6 foot	150	101	75	64	Gas	300.00	1,100.00	Irrigation	†7
679	do	do	F-15	1893	Bored, 7-inch	242	62	234	62	Wind	325.00	250.00	Domestic	
680	Hommel & Deuker	Rodeo de las Aguas.	E-13	1899	do	290	226	200	85	Hand	250.00		Stock	
681	do	do	E-13		Dug, 6 by 6 foot	290	Dry.	50						
682	do	do	E-13		Bored, 7-inch	300	234	75					Not used	
683	J. W. Wolfskill	Buenos Ayres	E-14	1903	Dug, 3-foot diameter	245	245	4	52	Hand			Domestic; stock	
684	Francisco Sabichi	La Ballona	E-15	1899	Bored, 7-inch	175	41	137	37	Wind	150.00	100.00	Domestic	
685	E. R. Taylor	do	E-15	1903	Bored, 8-inch	180	60	145	54	do	211.00	100.00	do	
686	C. W. Comstock	do	E-15		Bored, 4-inch	170	55	135	50	do		150.00	do	
687	C. A. Freeman	do	E-15	1888	Bored, 7-inch	180	55	150	50	do	150.00		do	
688	do	do	E-15	1888	do	180	55	150	50		150.00		Not used	
689	do	do	E-15	1888	do	180	55	150	50		150.00		do	
690	Geo. Lynn	do	E-15		Bored	187			47	Wind, gas		300.00	Domestic	
691	Mrs. C. Griffin	do	E-15		Bored, 7-inch	205	54	169		Wind	200.00	125.00	do	

693	W. K. Church	do	E-16	1902	Bored, 8-inch	204	54	300	61	Gas	2,000.00	250.00	do		
			E-16		Bored, 10-inch	201	54	305	56	Wind, gas	335.00	300.00	Domestic; irrigation.		
694	Mr. Driggs	do	E-16		Bored, 7-inch	163	71	200	81	Gas			Irrigation		
695	do	do	E-16		do	165	55	200	81	Wind	240.00	125.00	Domestic		
696	L. M. Kapp	do	E-16	1893	do	165	70	250	55	do	300.00	125.00	do		
697	Mrs. A. Nast	do	E-15		Bored	225	68	300	59	Gas			Irrigation		
698	Mrs. Nast	do	E-15		Bored, 7-inch	225	68	240	59	Wind			Irrigation; domestic.		
699	A. L. King	Las Bueyes	E-15	1899	do	230	70	240	66	do	300.00				
700	A. F. Gilmore	do	F-15		do	285	105	200	52	do		150.00	Stock		
701	do	do	F 14		do	200	97	105		do	125.00	100.00	do		
702	Mrs. E. Hughes	Buenos Ayres	D-14	1891	Bored, 4-inch	320	248	145	63	do	150.00	125.00	Domestic		
703	M. A. Wolfskill	do	D 14		Dug, 8 by 8 foot	270	264	12	36	do		100.00	Domestic; stock		
704	Pacific Land Co	Santa Monica	C 14	1902	Bored, 12-inch	255	212	550	70	Gas	1,000.00		Domestic		420
705	do	do	C 14	1899	do	255	210						Not used		
706	do	do	C-14		Bored, 10-inch	255	210	140	79				do		
707	do	do	C 14		do	255	210		79				do		
708	Peter Hayes	do	C 14	1902	Dug, 3 by 3 foot	255	203	52	72	Wind	72.00	200.00	Domestic		
709	Mrs. C. C. Willey	do	C-14	1902	Dug	238	170	70	66	do	30.00	150.00	do		
710	Frank Langdon	do	D 15	1900	Dug, 4 by 4 foot, 73 feet; bored, -inch, 47 feet.	228	161	120	67	do		200.00	do		
711	J. R. Fish	do	D-15	1903	Bored, 7-inch	208	142	125	56	do	150.00	100.00	do		
712	C. M. L. Hill	do	D-15	1902	Dug, 4 by 4 foot, 100 feet; bored, 7-inch, 103 feet.	198	73	203		do	329.00	125.00	do		
713	E. J. Calhoun	do	D-15	1903	Dug, 3 by 3 foot	193	122	73	63	Hand	75.00		do		
714	O. E. Bulfuns	do	D-15	1903	Bored, 7-inch	193	122	76	69	Wind	76.00	50.00	do		
715	Chris. Lundy	do	D-15	1902	do	188	125	219	66	do	342.50	150.00	do		
716	Mr. Bopes	do	D-15		do	173	90	127		Gas	150.00	450.00	Domestic; irrigation.		
717	Barnard and Oreb	La Ballona	D-15	1902	Bored	160	80	200	78	do			Irrigation		40
718	do	do	D-15	1883	Bored, 7-inch	160	90	250	78	Wind	300.00		Domestic		
719	S. Walters	do	D-15	1898	do	159	33	209	72	do	265.00	100.00	do		
720	W. M. Pitman	Santa Monica	D-15	1902	Dug, 3 by 3 foot	196	132	68	66	do	119.00	150.00	do		
721	Robert Mandell	do	D-15	1901	do	197	124	75		do	85.00	175.00	do		

Wells in Santa Monica quadrangle—Continued.

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722	Mrs. L. E. Allen	Santa Monica	D-15	1901	Dug, 3 by 3 foot.	203	125	85	68	Wind			Domestic	
723	E. E. Delano	do	D-15	1901	Bored, 7-inch	204	134	110	70	do	$125.00	$175.00	do	
724	W. H. Tucker	do	C-15	1901	Dug, 3 by 3 foot.	225	153	74	73	do	100.00	100.00	do	
725	Thomas F. Henry	do	C-15	1902	Bored, 7-inch	224	164	125	77	do	162.00	100.00	do	
726	H. K. Laird	do	C-14	1899	Dug, 3½ by 3½ foot.	247	187	70	76	do	70.00	275.00	do	
727	W. R. Chapman	do	C-15	1902	do	237	175	65	69	do	100.00	250.00	Domestic; irrigation.	
728	E. G. Woodward	do	C-15	1900	Dug, 3 by 3 foot.	227	163	68	75	do	100.00	250.00	Domestic	
729	E. S. West	do	C-15	1900	Dug, 4 by 4 foot.	226	164	65	77	do	100.00	225.00	do	
730	Mr. Bright	do	C-15	1900	Dug, 3 by 3 foot.	225	163	65	78	do	100.00	150.00	do	
731	Mathew Stewart	do	C-15	1901	do	224	157	72	77	do	100.00	175.00	do	
732	J. W. Taylor	do	C-15	1901	do	223	159	76	80	do	100.00	65.00	Domestic; irrigation.	
733	Chas. Howard	do	C-15	1900	do	220	153	70	76	do	100.00	65.00	Domestic	
734	A. Wiseman	do	C-15	1902	Dug, 3 by 3 foot, 76 feet; bored, 7-inch, 18 feet.	220	150	94	75	Gas	125.00	225.00	Irrigation	
735	do	do	C-15	1901	Dug, 3½ by 3½ foot.	218	150	70	75	Wind	100.00		Domestic	
736	J. S. Wiseman	do	C-15	1901	do	220	136	86	75	do	100.00	65.00	do	
737	O. E. Roberts	do	D-15	1902	Bored, 8-inch	194	122	130	71	Gas	180.00	700.00	Irrigation; domestic.	
738	E. H. Thornbrue	do	D-15	1902	Dug, 4 by 4 foot.	184	104	82	75	Hand	120.00		Domestic	
739	D. L. Allen	do	D-15	1902	Bored, 8-inch	179	89	160	78	Gas	234.00	580.00	Irrigation	9
740	D. D. Dooley	do	D-15	1902	Bored, 7-inch	171	96	145		do	188.00	200.00	Domestic; irrigation.	

741	Mr. Latour	do	D-15	1902	Dug, 4 by 4 foot.	166	91	80	80	Wind	125.00	100.00	Domestic		
742	Mr. Hanson	do	C-15	1902	Dug, 3 by 3 foot.	167	99	73	82	do	100.00	250.00	do		
743	A. N. King	do	D-15	1902	Bored, 7-inch	174	99	150	77	do	200.00	60.00	do		
744	P. W. Mallory	do	D-15	1903	Dug, 3 by 3 foot.	186	102	87	81	do	120.00	350.00	do		
745	John Barratt	do	C-15	1902	Dug, 3½ by 3½ foot.	191	111	83	76	do			do		
746	Richard Felch	do	C-15	1902	Dug, 3 by 3 foot.	191	105	90	78	do	125.00	75.00	do		
747	D. Kennedy	do	C-15	1901	do	193	111	86	81	do	125.00	75.00	do		
748	Mr. Majors	do	C-15	1902	Dug, 4 by 4 foot.	209	141	73	80	do	100.00	65.00	Irrigation		
749	C. J. Ekhalin	do	C-15	1902	Dug, 3 by 3 foot.	210	147	65	74	do	100.00	75.00	Domestic		
750	Dan Shibely	do	C-15	1901	Dug, 3½ by 3½ foot.	222	161	65	73	do	90.00	125.00	do		
751	J. W. Belote	do	C-15	1901	Bored, 7-inch	200	126	90	81	do	112.50	75.00	do		
752	J. B. Mallory	do	C-15	1902	Dug, 3½ by 3½ foot.	185	107	83	78	do	75.00	100.00	do		
753	Geo. W. Lacell	do	C-15	1902	Dug, 3 by 3 foot.	177	104	76	83	do	90.00	200.00	Domestic; irrigation.		
754	J. Murray	do	C-15	1902	do	173	105	74	80	do			Domestic		
755	C. M. Farr	do	C-15	1902	do	177	104	78	82	do	125.00	100.00	do		
756	J. C. Charles	do	C-15	1901	Bored, 7-inch	199	129	103	80	do	125.00	70.00	do		
757	L. P. Heldman	do	C-15	1901	Dug, 4 by 4 foot.	203	124	83	80	do	100.00	65.00	do		
758	D. Valdez	do	C-15	1902	Dug, 3 by 3 foot.	182	118	74	78	do	100.00	65.00	do		
759	Mr. White	do	C-15	1902	Bored, 16-inch	177	105	80	85	Hand	80.00		do		
760	Mrs. B. P. Diehl	do	C-15	1903	Bored, 8-inch	170	113	100	85	Wind	125.00	200.00	do		
761	J. L. Edwards	do	C-15	1902	Dug, 3 by 3 foot.	177	119	68	68	do	100.00	200.00	do		
762	John Charles	do	C-15	1902	Bored, 7-inch	181	121	106	84	do	80.00	144.00	do		
763	J. K. Thomas	do	C-15	1903	Dug, 3 by 3 foot, 84 feet; bored, 12-inch, 120 feet.	185	121	204	82	do	330.00	350.00	Domestic; irrigation.		
764	M. E. Robbins	do	C-15	1903	Dug, 3 by 3 foot.	185	106	83	85	do	100.00	133.00	Domestic		
765	H. M. Smith	do	C-15	1902	do	197	117	87	61	do	87.00	150.00	Domestic; irrigation.		
766	Chas. Fanetti	do	C-15	1901	do	189	124	70	80	Hand	100.00		Domestic		
767	Jasper Thomason	do	B-15	1902	Bored, 12-inch	186	110	300	67	Gas	675.00	715.00	Irrigation; domestic.		12
768	do	do	B-15	1900	Bored, 7-inch	179	99	120	67	Wind	150.00	100.00	Domestic; irrigation.		

Wells in Santa Monica quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
769	Jasper Thomason	Santa Monica	B-15		Bored, 7-inch	179	99	120	67	Wind	$135.00	$100.00	Domestic; irrigation.	
770	Carpenter & Dexter	do	B-15	1900	Bored, 10-inch	187	122	272	58	Gas		1,500.00	Irrigation	10
771	do	do	B-15	1897	do	184	116	80	70	Wind	100.00	175.00	do	
772	Mrs. L. H. Hubbel	do	B 16			160	100	100?	63	do		65.00	Domestic	
773	Chas. Jenkins	do	B-15	1903	Bored, 7-inch	175	110	119	58	do	150.00	150.00	do	
775	N. R. Brown	La Ballona	C 16		do	148	59	104	75	do	100.00	65.00	Domestic; stock	
776	A. L. Whittaker	do	C 16	1899	Bored, 8-inch	190	63	315	81	do	600.00	250.00	Domestic	
777	do	do	C 16		Bored, 7-inch	190	63	130		Not used				
778	Jonathan Tibbets	do	D-16	1880	do	137	44	98	73	Wind	100.00		Domestic	
779	L. C. Brown	do	D-16		do	137	59	86	74	do	100.00	125.00	do	
780	Tom Attrill	do	D-16	1902	do	138	44	126	74	do	135.00	65.00	do	
781	R. D. Pontius	do	D-16	1900	do	138	48	200		Gas	300.00	300.00	Domestic; irrigation.	4
782	Alonzo C. Smith	do	E-16		Dug, 3 by 3 foot	138	Dry.	78						
783	do	do	E-16		Bored, 7-inch	138	40	106	76	Wind	125.00	65.00	Domestic; stock	
784	C. Wicks	do	D-15	1903	Bored, 12-inch	149	59	319	58	Gas	660.00	1,075.00	Domestic; irrigation.	15
785	Alonzo C. Smith	do	D-15		Bored, 7-inch	159	Dry.	87			100.00			
786	A. Beal	do	F-16	1896	Dug, 3 by 3 foot.	141	105	36	57	Hand	50.00		Domestic	
787	do	Los Bueyes	F-16	1896	Dug, 4½ by 6 foot	130	88	103	59	Gas	500.00	700.00	Irrigation	
788	E. Kubis	La Ballona	F-16	1902	Dug, 3 by 3 foot.	135	98	42	65	do	60.00	225.00	Domestic; irrigation.	†3
789	Y. Nishi	do	F-16	1899	Bored, 7-inch	128	98	76	68	Wind	75.00	75.00	Domestic	
790	Mrs. E. L. Highley	do	F-16	1895	Dug, 3-foot diameter.	122	90	37	65	do	75.00	65.00	do	

791	*Newmark & Edwards*.....	*do*.....	D-16....	1894	Bored, 7-inch...	128	52	94	77	.....do.....	100.00	75.00	Domestic; stock..	.....
792	M. Stevens.....	.....do.....	D-16....	1894	.....do.....	120	48	82	89	.....do.....	80.00	65.00	Domestic.....	.....
793	Jacob Brown.....	.....do.....	D-16....	1897	Dug, 3 by 3 foot, 60 feet; bored, 4-inch, 140 feet.	118	56	200	71	.....do.....	350.00	100.00	.....do.....	.....
794	Newmark & Edwards.	.....do.....	D-16.....		Bored, 7-inch...	115	47	72	.....	.....do.....	75.00	65.00	.....do.....	.....
795	L. Lorbeer.....	.....do.....	E-16....	1884	.....do.....	120	53	87	59	.....do.....	90.00	95.00	.....do.....	.....
796	N. P. Cole.....	.....do.....	E-17....	1884	.....do.....	118	58	88	55	.....do.....	110.00	150.00	Domestic; stock..	.....
797	Arnold Schaub.....	.....do.....	E-16.....		.....do.....	138	54	130	53	.....do.....	150.00	65.00	Domestic.....	.....
798	D. S. Bryant.....	.....do.....	E-16....	1898	.....do.....	130	65	105	39	.....do.....	125.00	65.00	.....do.....	.....
799	C. Valdez.....	.....do.....	E-16....	1889	Dug, 3 by 3 foot.	145	48	100	65	.....do.....	100.00	125.00	.....do.....	.....
800	Andres Ybarra.....	.....do.....	E-16....	1901	.....do.....	105	63	46	40	Hand.....	50.00	.....	.....do.....	.....
801	John Lestelle.....	.....do.....	E-16....	1902	.....do.....	105	63	47	39	.....do.....	.....	.....	.....do.....	.....
802	Jesus Saenz.....	.....do.....	E-16....	1901	.....do.....	148	47	102	80	.....do.....	100.00	.....	.....do.....	.....
803	John Skillman.....	.....do.....	E-16....	1902	Bored, 8-inch...	145	50	180	29	Wind.....	280.00	75.00	.....do.....	.....
804	James McKee.....	.....do.....	E-16....	1902	Dug, 3½ by 3½ foot.	150	94	59	102	.....do.....	60.00	50.00	.....do.....	.....
805	J. S. Lowe.....	.....do.....	E-16.....		Bored, 7-inch...	175	96	106	68	.....do.....	125.00	65.00	.....do.....	.....
806	C. A. Winship.....	.....do.....	F-16....	1886	Dug, 6 by 4 foot.	137	107	45	....	Gas.....	.....	.....	.....do.....	.....
807	....do.....	.....do.....	F-16....	1886	Dug, 4 by 6 foot.	137	107	45	.....	.....do.....	.....	.....	.....do.....	.....
808	G. P. Shanks.....	.....do.....	F-16....	1896	Dug, 3½ by 3½ foot.	135	107	40	72	Wind.....	40.00	65.00	.....do.....	.....
809	I. Fellows.....	.....do.....	F-16....	1893	Dug, 4 by 4 foot.	134	107	37	133	.....do.....	40.00	100.00	.....do.....	.....
810	John Coyner.....	.....do.....	F-16.....		Dug, 3½ foot diameter.	108	78	37	60	.....do.....	50.00	50.00	.....do.....	.....
811	W. R. Scurlock.....	.....do.....	F-16....	1893	Bored, 7-inch...	104	77	72	60	.....do.....	75.00	100.00	....do.....	.....
812	Palms Catholic Church	.....do.....	F-16....	1898	Dug, 4 by 4 foot.	99	74	27	58	.....do.....	30.00	65.00	.....do.....	.....
813	Los Angeles Co.....	.....do.....	F-16.....		Bored, 7-inch...	95	72	98	56	.....do.....	100.00	125.00	Roads.....	.....
814	Geo. Charnock.....	.....do.....	E-16....	1889	.....do.....	121	65	80	88	.....do.....	80.00	150.00	Domestic.....	.....
815	John Monlon.....	.....do.....	E-16....	1901	Dug, 3 by 3 foot.	126	80	50	69	.....do.....	50.00	65.00	.....do.....	.....
816	Martin Brown.....	.....do.....	E-16.....		Bored, 7-inch...	136	93	60	85	.....do.....	75.00	100.00	.....do.....	.....
817	Mrs. L. J. DePee.....	.....do.....	E-16....	1902	.....do.....	125	74	176	60	.....do.....	225.00	100.00	.....do.....	.....
818	Ed Bryant.....	.....do.....	E-16....	1901	Dug, 4 by 4 foot.	130	70	80	73	Hand.....	80.00	.....	.....do.....	.....
819	D. Moriarty.....	.....do.....	F-16....	1899	Dug, 3 by 3 foot.	125	75	63	82	Wind.....	*250.00	.....	.....do.....	.....
820	M. F. Kane.....	.....do.....	F-16....	1901	Bored, 7-inch...	125	74	250?	65	.....do.....	*500.00	.....	.....do.....	.....
821	J. P. Ward.....	.....do.....	F-16.....		.....do.....	130	72	75	61	.....do.....	75.00	75.00	.....do.....	.....

Wells in Santa Monica quadrangle—Continued.

Number of well	Owner.	Location.	Map location.	Year completed	Class of well.	Elevation of surface (feet).	Elevation of water (feet)	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
822	F. E. Schuedig	La Ballona	F 16	1902	Dug, 4 foot diameter.	123	74	54	47	Gas	$150.00	$250.00	Domestic	
823	Robert Lowe	do	F 16	1889	Dug, 4 by 4 foot.	120	79	45	42	Wind	45.00	65.00	do	
824	W. W. LaForge	do	F 16	1901	Dug, 3½ by 3½ foot.	117	80	42	58	do			do	
825	Calvin Ford	do	F 16	1901	Dug	115	78	45	44	Hand	50.00		do	
826	G. Kidson	do	F 16	1888	Bored, 7-inch	109	86	48	103	Wind			do	
827	Chas. Ford	do	F 16	1902	do	116	85	52	15	do		65.00	do	
828	United Brethren Church.	do	F 16		Dug, 4 by 4 foot.	120	78	46	45	do	50.00	100.00	do	
829	F. P. Bojorquez	do	E 16		do	118	74	50	65	do	50.00	100.00	do	
830	L. McDonnell	do	F 16	1899	Bored, 7-inch	110	77	77	35	do	80.00	50.00	do	
831	L. Machado	do	E F 16	1880	do	110	83	42	20	do	50.00	75.00	do	
832	J. J. Chapman	do	F 16		do	110	28	95	40	do	100.00	100.00	do	
833	F. P. Bojorquez	do	F 16	1891	do	100	54	66	30	do	75.00	100.00	do	
834	Jesus Saenz	do	F 16		Bored, 5-inch	90	41	56	52	do	50.00	75.00	do	
835	J. Illich Estate	do	F 16	1885	Bored, 7-inch	85	45	47	70	do	50.00	75.00	do	
836	C. E. Stanton	do	D 17	1903	Bored, 8¼-inch	136	28	180	77	do	250.00	65.00	do	
837	J. S. Cripe	do	D 17	1888	Bored, 7-inch	98	38	100	75	Hand			do	
838	Jacob Brown	do	D 17	1900	Dug, 3 by 3 foot.	75	27	50	77	do			do	
839	T. L. Gooch	do	D 17	1903	Bored, 12-inch	70	36	150	75	Gas	175.00	1,700.00	Irrigation	60
840	H. McClelland	do	D 17	1903	Bored, 7-inch	74	29	62	75	Hand	60.00		Domestic	
841	Artesian Water Co	do	D 17	1883	do	90	27	72	74	Wind	75.00	65.00	Domestic; stock	
842	Henry Lowe	do	D 17	1884	do	97	27	110	77	do	100.00	75.00	Domestic	
843	F. B. Koen	do	D 17	1888	do	87	28	105	67	Gas	100.00	200.00	do	

891	Daniel Maloy	do	B-16	1902	Bored, 12-inch	200	90	140	70	do	$100.00	$70.00	do		
892	Mr. Dunham	do	B-15		do	175	105	275					Not used		
893	do	do	B-15		do	175	103	99	47	Wind	100.00		Domestic		
894	H. T. Maloy	do	B,C-15	1902	Bored, 12-inch	180	122	280					Not used		
895	Mrs. J. E. Boyce	do	B 15	1895	Bored, 7-inch	190	110	104	46	Wind	125.00	100.00	Domestic		
896	Phillip Flynn	do	B-15	1886	do	210	86	170	36	do			do		
897	Roy Jones	do	B-15		Bored, 12-inch	200	66	900			3,000.00		Not used		
898	John Carsons	do	B-16	1902	Bored, 7-inch	167	57	191	73	Wind	257.85	800.00	Domestic		
899	Golden State Land and Floral Co.	do	B 16	1901	do	153	43	151	58	Gas			Irrigation		
900	Miss M. J. Webster	do	B 16	1897	Bored, 6-inch	153	54	114	46	Wind	100.00		Domestic		
901	John E. Hackett	do	B 16		Bored, 7-inch	150	49	135	72	do	150.00		do		
902	S. E. Penn	do	A 16	1903	do	130	40	134		do	167.50	180.00	do		
903	Wm. Campbell	do	A 16	1898	do	133	40	150	62	do	200.00	100.00	do		
904	B. L. Balsley	do	A 16	1900	do	120	51	134	61	Gas	185.00	450.00	do		5
905	W. Arnett	do	A-16	1895	do	112	26	100	98	Wind	100.00	75.00	do		
906	United Electric Gas and Power Co.	do	A-16		do	100	35	200		Steam			Manufacturing		
907	Santa Monica Steam Laundry.	do	A-17,16	1902	Bored, 12-inch	90	40	108	76	do	100.00		Laundry		
908	J. R. Armstrong	do	A-16,17	1901	Dug, 4 by 6 foot	99	40	75	68	Gas	1,000.00	750.00	Irrigation		20
909	C. Johnson	La Ballona	B-17	1890?	Dug, 3 by 3 foot	100	47	56	47	Wind	60.00	75.00	Domestic		
910	J. Monricas	do	B-17	1898	do	50	12	45	75	do					
911	E. Knecht	do	B 17	1896	Dug, 7 by 7 foot	40	21	31	70	do		95.20	Domestic		
912	Mr. Lee	do	B 17		Dug, 4 by 4 foot	30	20	14	118	do					
913	Geo. Carter	do	B-17	1902	Bored, 16-inch	48	11	47	96	do	50.00	75.00	Domestic		
914	Joe Burkhart	do	B-17	1903	Dug, 8 by 10 foot	38	30	30	200+	Gas			Irrigation		
915	Antonio Machado	do	C-17		Bored, 7-inch	60	35	34	53	Wind	50.00	75.00	Domestic; stock		
916	Augustin Cota	do	C-17	1891	Dug, 4 by 4 foot	51	33	25	47	Hand			Domestic		
917	H. W. Cripe	do	D-17	1893	Bored, 7-inch	96	18	85	74	Wind	100.00	100.00	do		
918	Mrs. R Olivera	do	C-17	1890	Dug, 4 by 4 foot	50	35	22	92	Hand			do		
919	Augustin Cota	do	C-17	1890	do	50	27	30	54	Wind			Stock		
920	Mrs. A. Altamiramo	do	C-17	1894	do	45	34	14	118	Hand			Domestic		
921	Visenta de Mutaw	do	C-17	1898	Dug, 3 by 3 foot	46	34	14	101	Wind			do		
922	Garrison & Smith	do	B-17	1903	Bored, 12-inch	60	17	63	60	Gas			Irrigation		

Wells in Santa Monica quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
875	Artesian Water Co ...	Santa Monica	B-15....	1902	Bored, 10-inch..	237	230	164	72	Compressed air...	.....	.....	Domestic.....	16
876	.....do.....	.....do.....	B, C-15.	1900	.....do.....	230	221	150	.....	.....	.....	.....	Not used.....	.....
877	.....do.....	.....do.....	C-14,15.		Dug, 1 by 4 foot.	225	222	4	50	Hand.....	.....	.....	Domestic.....	.....
878	.....do.....	.....do.....	C-14		Bored, 7-inch ...	230	226		51	.....	.....	.....	Not used.....	.....
879	.....do.....	.....do.....	C-14		Dug, 5 by 5 foot, 30 feet; bored, 8-inch.	250	220		72	Tunnel.....	.....	.....	Domestic.....	.....
880	.....do.....	.....do.....	C-14		Dug, 6 by 6 foot, 30 feet; bored, 12-inch, 59 feet.	235	215	89	88	.....do.....	.....	.....	.....do.....	.....
881	.....do.....	.....do.....	C-14		Dug, 4 by 5 foot, 20 feet; bored, 6-inch, 248 feet.	235	215	268	88	.....do.....	.....	.....	.....do.....	.....
882	.....do.....	.....do.....	C-14		Dug, 4 by 5 foot, 20 feet; bored, 6-inch, 120 feet.	235	217	140	85	.....do.....	.....	.....	.....do.....	.....
883	.....do.....	.....do.....	C-14		Dug, 4 by 5 foot, 30 feet; bored, 10-inch, 270 feet.	235	211	300	86	.....do.....	.....	.....	.....do.....	.....
884	.....do.....	.....do.....	C-14		Dug, 4 by 5 foot, 30 feet; bored, 7-inch.	235	205		86	.....do.....	.....	.....	.....do.....	.....
885	.....do.....	.....do.....	C-14		Bored, 12-inch.	235	213	55	85	.....	.....	.....	.....	.....
886	.....do.....	.....do.....	C-14		.....do.....	235	212	56	85	.....	.....	.....	.....	.....
887	.....do.....	.....do.....	C-14		.....do.....	235	212	90	85	.....	.....	.....	.....	.....
888	.....do.....	.....do.....	C-14		.....do.....	235	212	90	85	.....	.....	.....	.....	.....
889	.....do.....	.....do.....	C-14		Dug, bored, 12-inch.	235	215	89	88	Tunnel.....	.....	.....	Domestic.....	.....

949	Rance Hermann	do	A-17	1897	Dug, 4-foot diameter.	40	18	24		do			do		
950	J. Haffner	do	A 17	1883	Dug, 4 by 4 foot.	42	19	26	154	do	30.00	116.00	do		
951	F. H. Hostetter	do	A 17	1888	Bored, 7-inch	50	17	39	67	do	45.00	75.00	do		
952	S. Thomas	do	A 17	1898	Dug, 3 by 3 foot.	65	18	55	200+	do	60.00	50.00	do		
953	[illegible] McLaughlin	do	E 17	1892	Bored, 7-inch	79	65	50	40	do	50.00	75.00	do		
954	Mrs. H. McKee	do	E 17		do	78	58	33	43	do	40.00	75.00	do		
955	[illegible] Knauer	do	F 17		Dug, 3 by 3 foot.	78	58	22	62	Hand			do		
956	Mrs. M. F. Platt	do	E 17		do	79	58	26	54	Wind		75.00	do		
957	Belvedere school district	do	F 17		Bored, 7-inch	82	50	52	60	do	65.00	100.00	do		
958	D. J. Boynton	do	F 17		do	85	45	60	32	do	75.00	100.00	Domestic; irrigation.		
959	Sunset Brick and Tile Co.	Santa Monica	B 16	1903	Bored, 12-inch	160							Manufacturing		
960	Mr. Kirkhoff	Los Angeles city	M 15		Bored, 7-inch	200	Dry	59							
961	Wm. Bayly	do	M 16		do	205	140	88					Not used		
962	Andrew Cowan	do	M 16	1890	do	198	137	101	66	Wind			Domestic		
963	Phos. Wolfe	do	M 16	1889?	Bored	195	136	85					Not used		
964	Dr. Phelps	do	L 16		Bored, 7-inch	190	135?	80?		Wind			Domestic		
965	L. H. McKnight	do	M 16		do	210	148	64					Not used		
966	Berlin Dye Works	do	N 16	1902	Bored, 12-inch	230	145?	120	59	Electric motor			Manufacturing		†3
969	L. Snodgrass	do	N 16	1883?	Bored, 7-inch	225	Dry.	73							
970	F. H. Limsenbard	do	M 15	1882?	do	225	Dry.	80							
971	Los Angeles Interurban Railway	do	M 15	1902?	Bored, 9-inch	235	110?	625					Not used		
972	Otto Wandrey	do	L-15	1883?	Bored, 7-inch	215	151	67	59	Wind			Domestic		
973	A. H. Van Guysling	do	L 15	1884?	Dug, 60 feet; bored, 18 feet.	220	154	78	72	do			do		
974	Geo. R. Cooper	do	L 15	1884?	Bored	200	125?	175	51	do			do		
975	C. P. Clark	do	L 15	1894?	Bored, 7-inch	215	125?	120?	74	do			do		
976	Westlake Oil Co.	do	L-13	1901	Bored, 7½-inch, 385 feet; bored, 5½-inch, 155 feet.	275		510					Boilers		

Wells in Santa Monica quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
923	A. R. Tobey	La Ballona	B-17	1899	Bored, 7-inch	130	15	150	45	Wind	$300.00		Domestic	
924	Joseph Burkhart	do	B-17		Bored, 6-inch	130	20	440	56	do	600.00	$250.00	do	
925	Sheldon Tobey	do	B-17	1900	Bored, 7-inch	138	15	147	54	do	160.00	100.00	do	
926	Wm. Simpson	do	B-17	1890	Bored, 6-inch	130	22	125	65	do	140.00	100.00	do	
927	Andrew Comstock	do	B-17	1899	Bored, 3-inch	95	15	100	45	do			do	
928	do	do	B-17	1900	Bored, 16-inch	90	15	90	48				Not used	
929	City of Santa Monica	Santa Monica	B-16	1896	Bored, 7-inch	135	23	135	79	Wind	150.00	125.00	Domestic; irrigation.	
930	F. M. Doyle	La Ballona	B 16	1888	do	150	29	128	83	do	150 00	75.00	Domestic	
931	H. C. Bray	do	B-16	1894	do	150	30	138	72	do	157.00	75.00	do	
932	W. O. Irwin	do	B-17	1899	do	145	23	148	64	Gas, wind	165.00	200.00	Domestic; irrigation.	
933	John Ban Dam	do	B-17	1896	do	145	23	147	50	Wind			Domestic	
934	Lewis Bach	do	B-17	1903	Bored, 10-inch	148	19	140	81	do	310.00	200.00	do	
935	G. S. Cornell	do	B-17	1902	Bored, 7-inch	141	23	130	64	do	150.00	75.00	do	
936	Wm. Jackson	do	B 17	1902	Bored, 6-inch	136	23	126?	67	Gas, wind			Domestic; irrigation.	
937	do	do	B-17	1900	do	136	23	126			150.00		Not used	
938	A. Gunn	Santa Monica	A-17		Bored, 16-inch	100	31	85		Wind			Domestic; irrigation.	
939	H. B. Houghton	do	A-17	1901	Dug, 3 by 3 foot	100	34	68	70	do	70.00	100.00	Domestic	
940	T. M. Holbert	do	A-17	1883	do	100	34	68	103	do	70.00	75.00	do	
941	J. E. Simmons	La Ballona	A, B-17	1898	Bored, 12-inch	100	31	80	70	do	150.00	45.00	do	
942	Maurice Macklin	do	A-17		Bored, 8-inch	120	20	115	70	do			do	
943	Roy Jones	Santa Monica	A-14		Dug, 4 by 4 foot	375	318	65	120	Hand				
944	do		A-17		do					do			Domestic	

945	D. F. Dominick	La Ballona	A-17	1886	Dug, 6 by [illegible]	60	18	50	106	.....	50.00	75.00	.....	.....	
946	J. A. Colvert	....do	A-17	1893?	Dug, 2 by 2 foot.	60	17	103	.....	....do	50.00	75.00	....do	.....	
947	H. C. Morse	....do	A-17	1903	Bored, 7-inch	40	17	103	.....	....do	154.50	250.00	....do	.....	
948	M. E. Biggs	....do	A-17	.....	Dug, 4 by 4 foot.	48	19	33	96	....do	.....	.....	....do	.....	
949	Rance Hermann	....do	A-17	1897	Dug, 4-foot diameter.	40	18	24	.....	....do	.....	.....	....do	.....	
950	J. Haffner	....do	A-17	1883	Dug, 4 by 4 foot.	42	19	26	154	....do	30.00	116.00	....do	.....	
951	E. L. Hostetter	....do	A-17	1888	Bored, 7-inch	50	17	39	67	....do	45.00	75.00	....do	.....	
952	S. Thomas	....do	A-17	1898	Dug, 3 by 3 foot.	65	18	55	200+	....do	60.00	50.00	....do	.....	
953	Geo. McLaughlin	....do	E-17	1892	Bored, 7-inch	79	65	50	40	....do	50.00	75.00	....do	.....	
954	Mrs. H. McKee	....do	E-17	.....	....do	78	58	33	43	....do	40.00	75.00	....do	.....	
955	Gus. Kruger	....do	E-17	.....	Dug, 3 by 3 foot.	78	58	22	62	Hand	.....	.....	....do	.....	
956	Mrs. M. E. Platt	....do	E-17	.....	....do	70	58	26	54	Wind	.....	75.00	....do	.....	
957	Ballona school district	....do	E-17	.....	Bored, 7-inch	82	50	52	60	....do	65.00	100.00	....do	.....	
958	D. J. Boynton	....do	F-17	.....	....do	85	45	60	32	....do	75.00	100.00	Domestic; irrigation.	.....	
959	Sunset Brick and Tile Co.	Santa Monica	B-16	1903	Bored, 12-inch	160	.....	.....	.....	.....	.....	.....	Manufacturing	.....	
961	Mr. Kirkhoff	Los Angeles city	M-15	.....	Bored, 7-inch	200	Dry	59	.....	.....	.....	.....	.....	.....	
962	Wm. Bayly	....do	M-16	.....	....do	205	140	88	.....	.....	.....	.....	Not used	.....	
963	Andrew Conlan	....do	M-16	1890	....do	198	137	101	66	Wind	.....	.....	Domestic	.....	
964	Thos. Wolfe	....do	M-16	1889?	Bored	195	136	85	.....	.....	.....	.....	Not used	.....	
965	Dr. Phelps	....do	L-16	.....	Bored, 7-inch	190	135?	80?	.....	Wind	.....	.....	Domestic	.....	
966	J. H. McKnight	....do	M-16	.....	....do	210	148	64	.....	.....	.....	.....	Not used	.....	
968	Berlin Dye Works	....do	N-16	1902	Bored, 12-inch	220	145?	120	59	Electric motor	.....	.....	Manufacturing	†3	
969	L. Snodgrass	....do	N-16	1883?	Bored, 7-inch	225	Dry.	73	.....	.....	.....	.....	.....	.....	
970	E. H. Limsenbard	....do	M-15	1882?	....do	225	Dry.	80	.....	.....	.....	.....	.....	.....	
971	Los Angeles Interurban Railway.	....do	M-15	1902?	Bored, 9-inch	235	110?	625	.....	.....	.....	.....	Not used	.....	
972	Otto Wandrey	....do	L-15	1893?	Bored, 7-inch	215	151	67	59	Wind	.....	.....	Domestic	.....	
973	A. H. Van Guysling	....do	L-15	1884?	Dug, 60 feet; bored, 18 feet.	220	154	78	72	....do	.....	.....	....do	.....	
974	Geo. R. Cooper	....do	L-15	1884?	Bored	200	125?	175	51	....do	.....	.....	....do	.....	
975	C. P. Clark	....do	L-15	1894?	Bored, 7-inch	215	125?	120?	74	....do	.....	.....	....do	.....	
976	Westlake Oil Co	....do	L-13	1901	Bored, 7¼-inch, 385 feet; bored, 5¾-inch, 155 feet.	275	.....	510	.....	.....	.....	.....	Boilers	.....	

Wells in Santa Monica quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well.	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
977	Westlake Oil Co	Los Angeles city	L-13	1902	Bored, 6-inch	280	255	1,500	150+				Boilers	
978	A. K. Waters	do	M-13	1897	Dug, 4 by 4 foot, 76 feet; bored, 7-inch, 33 feet.	405	339	109	29	Wind	$400.00		Domestic	
979	Mr. Thayer	do	N-12		Dug, 3½-foot diameter.	390	345	61	58	do			do	
980	E. P. Blackmar	Los Felis	M-11		Dug, 3 by 3 foot.	390	272	22	69	do			Domestic; irrigation.	
981	E. Beck	do	M-12	1902	do	400	5577	45	62	do			Domestic	
982	G. M. Thayer	do	M-10		Dug, 4 by 4 foot, 41 feet; bored, 7-inch, 9 feet.	440	400	50	140	do			do	
983	L. K. Westcott	do	M-10		Dug, 4-foot diameter.	450	370	79	69	do			do	
984	Mrs. S. G. Thompson	do	M-10	1892?	Dug, 20-inch diameter.	500	485	18	29	do			do	
985	Jose Salazar	do	N-10	1903	Dug, 3 by 4 foot.	450	438	13		Hand			do	
986	L. A. City	do	N-11	1898	Dug, 4 by 4 foot.	435	396	49		do			Stock	
987	Jose Garcia	do	N-10	1903	do	450		33		Wind			Domestic	
988	C. A. McCoy	Los Angeles city	N-12	1903?	Dug, 4 by 6 foot.	500	474	28	53	do			do	
989	Haggard & Shepard	do	N-13		Dug, 4-foot diameter.	390	361	31	141				Not used	
991	Frank Whitmore	do	N-11	1903	Dug, 4 by 4 foot.	480	436	46	31	Hand			Stock	
992	Jacob Fader	do	N-12	1896	Dug, 5 by 5 foot.	440	416	28	40	Wind			Domestic	
993	Mr. Clark	do	N-12	1900?	Dug, 3 by 4 foot.	425	398	33	52	do			do	
994	John Maier	do	N-12	1899?	Dug	460	444	22	62	do			do	
995	Elysian Water Co	do	N-12	1899	do	550	528	32	22	do			do	

996	Crystal Water				Mineer.									
997	C. R. Cummings	....do	N-12	1903	Dug, 4 by 4 foot.	600	542	65	25	....do			....do	
998	Felipe Botiller	....do	N-15	1893	Bored, 7-inch	240		100		....do			Not used	
999	Pacific Electric R. R. Co.	Los Bueyes	F-16	1903	Bored, 12-inch	110	75	125		Gas			Power house	
1000	H. D. Lombard	Rodeo de las Aguas.	H-14	1905	Bored, 12-inch (3).	150	114	170		Not installed			Will be used for irrigation.	

Wells in Redondo quadrangle.

* Cost of well and equipment combined. + Tank included in column "Cost of machinery." † Yield estimated or statement of owner taken. ? Doubtful.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
1	Ocean Park Water Co	La Ballona	B 1	1903	Bored, 10-inch	75	42	87	82	Gas			Domestic	
2	....do	....do	B-1	1902	....do	75	42	88	79	....do			....do	
3	M. Baldridge	....do	B-1	1896	Bored, 6-inch	90	40	100	79	Wind			....do	
4	W. S. Vawter	....do	B-1		Bored	87	42	80	78	Wind, gas			Domestic; irrigation.	
5	A. P. Olivares	....do	B-1	1892	Dug, 4 by 4 foot.	42	14	32	73	Wind	$40.00	$75.00	Domestic	
6	E. J. Vawter	....do	B-1		Dug, 5 by 10 foot	40	12	89	67	Gas			Irrigation	25
7	D. J. Machado	....do	B-1	1888	Dug, 3 by 3 foot.	41	12	30	75	Wind	30.00	75.00	Domestic	
8	M. Higuera	....do	B-1		....do	38	12	30	82	....do	30.00	75.00	....do	
9	I. A. Jameson	....do	B-1	1900	Dug, 3 by 4 foot.	38	12	30	79	Gas	30.00		Manufacturing	
10	United Electric Gas and Power Co.	....do	B-1	1903	Dug, 23 feet; bored, 12-inch, 28 feet.	38	14	51	78	Steam	100.00		....do	
11	E. J. Vawter	....do	B-1		Bored, 7-inch	40	13	30	102	Wind	35.00	75.00	Domestic	
12	Abbott Kinney & Co	....do	B-1	1902	Bored, 15-inch	35	17	93	86	Gas			....do	

Wells in Redondo quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
13	Abbott Kinney & Co..	La Ballona.....	B-1.....	1900	Bored, 10-inch..	35	19	99	86	Gas.....	.....	.....	Domestic.....	.....
14	.....do.....	.....do.....	B-1.....	1892	Bored, 7-inch...	35	19	100	86	.....do.....	.....	.....	.....do.....	.....
15	Mrs. Mary Mead.....	.....do.....	B-1.....	1897	Dug, 3 by 3 foot.	15	45	32	68	Wind.....	.....	.....	.....do.....	.....
16	Thos. Menzier	.....do.....	A, B-1..	1898	.....do.....	34	14	22	.....	.....do.....	$25.00	$75.00	.....do.....	.....
17	Ocean Park Laundry .	.....do.....	A-1.....	1903	Dug, 23 feet; bored, 8-inch, 74 feet.	45	15	107	109	Steam.....	125.00	.....	Laundry.....	.....
18	A. D. Keating.....	.....do.....	C-1.....	1898	Dug, 4 by 4 foot.	30	13	19	72	Wind.....	.....	75.00	Domestic.....	.....
19	Geo. Lawson.....	.....do.....	C-1.....	1902	Dug, 3 by 4 foot.	30	13	20	74	Hand.....	.....	.....	Irrigation.....	.....
20	H. Knutson.....	.....do.....	C-1.....	.....	Bored, 10-inch..	22	14	45	.....	Gas.....	.....	.....	.....do.....	.....
21	Winan & Son	.....do.....	C-1.....	1903	Bored, 12-inch..	28	12	40	72	.....	.....	.....	.....	.....
22	Wm Sweeney	.....do.....	C-1.....	.....	Dug, 3 by 3 foot.	30	13	22	77	Wind.....	.....	45.00	Domestic; stock..	.....
23	B. Luegel.....	.....do.....	C-1.....	1895	Dug, 4 by 4 foot.	30	13	19	100	Hand.....	20.00	.....	Domestic.....	.....
24	C. J. Frederick.....	.....do.....	C-1.....	1898	.....do.....	29	13	18	108	Wind.....	20.00	.....	.....do.....	.....
25	L. C. Miller.....	.....do.....	C-1.....	1901	Dug, 31 feet; bored, 12-inch, 39 feet.	42	24	70	91	Gas.....	200.00	950.00	Irrigation.....	†90
26	.....do.....	.....do.....	C-1.....	1803	Bored, 7-inch...	42	24	76	86	Wind.....	76.00	100.00	Domestic.....	.....
27	Wm. Hume.....	.....do.....	C-1.....	.....	Bored, 12-inch..	26	15	84	.....	Gas.....	100.00	1,000.00	Irrigation.....	†50
28	.....do.....	.....do.....	C-1.....	1895	Bored, 14-inch..	26	16	23	.....	.....do.....	.....	.....	.....do.....	.....
29	.....do.....	.....do.....	C-1.....	.....	.....do.....	26	16	22	.....	.....do.....	.....	.....	.....do.....	.....
30	.....do.....	.....do.....	C-1.....	.....	Dug, 4 by 4 foot.	26	16	17	98	Wind.....	.....	.....	Domestic.....	.....
31	.....do.....	.....do.....	C-1.....	.....	.....do	25	19	10	.....	.....	.....	.....	Stock.....	.....
32	E. Tanny.....	.....do.....	C-1.....	.....	.....do	26	20	12	86	Horsepower.....	.....	.....	Irrigation.....	.....
33	A. Soreet.....	.....do.....	C-1.....	1897	Dug, 3 by 3 foot.	26	19	12	86	Wind.....	.....	.....	Domestic.....	.....

89	....do	....do	F-2	1901	....do	23	16	10	108	....do			....do		
90	....do	....do	E-2		....do	17	9	25	173	....do	25.00		Stock		
91	R. Machado	....do	E-2		Dug, 3 by 3 foot.	17	10	10	89	....do			Domestic		
92	J. Mesmer	....do	E 2		Dug, 4 by 4 foot.	20	15	10	89	....do			....do		
93	....do	....do	E 2		Bored, 4-inch...	16	16		71	Artesian			Stock		1
94	....do	....do	E 3	1902	Bored, 12-inch..	15	15	45	72	Gas, artesian			Duck pond		
95	....do	....do	E 3	1902	....do	15	15	92	72	....do			....do		
96	....do	....do	E 3	1902	....do	15	15	87	72	....do			....do		
97	....do	....do	E 3		....do	15	15	38	72	....do			....do		
98	....do	....do	E 3	1902	....do	15	15	57	72	....do			....do		
99	....do	....do	E 3	1902	Bored, 6½-inch..	21	16	24	72	Hand			Domestic		
100	....do	....do	E 2		Dug, 4 by 4 foot.	20	16	9	86	....do			Stock		
101	A. D. Keating	....do	F 1	1902	....do	35	30	8	230+	Wind			....do		
102	Mrs. Ida Nues	....do	F 1	1897	Dug, 3 by 3 foot.	40	35	9	101	Hand			Domestic		
103	Manuel Perez	....do	F 1	1881	....do	44	39	10	106	....do			....do		
104	M. Lugo	....do	F 1	1902	....do	40	43	12	94	....do			....do		
105	C. Peters	....do	F 1		Dug, 3½ by 3½ foot.	48	39	14	115	....do			....do		
106	Joseph Faulk	....do	F 1		Dug, 3 by 3 foot.	49	41	12	96	....do			....do		
107	A. Machado	....do	F 1		....do	40	34	10	94	....do			Stock		
108	B. Machado	....do	F-1		Dug, 3 by 4 foot.	40	36	8	93	Wind			....do		
109	Mrs. Ida Niles	....do	F-1	1902	Dug, 4 by 4 foot.	46	31	17	158	Hand	20.00		Domestic		
110	C. Oliveras	....do	G-1		Dug, 3½ by 3½ foot.	48	36	14	94	....do			....do		
111	....do	....do	G-1	1889	Dug, 2 by 3 foot.	70	36	37	72	....do	35.00		....do		
112	A. Machado	....do	G-1	1885	Dug, 4 by 4 foot.	60	39	23	98	....do			....do		
113	M. Perez	....do	G-1	1903	Bored, 7-inch...	100	21	96	76	Wind		65.00	....do		
114	L. Sentons	....do	G-1	1903	Bored, 8-inch...	175	19	163	71	....do		75.00	Stock		
115	T. Oliveras estate	....do	E-1	1888	Bored, 7-inch...	66	40	35		....do	35.00	75.00	Domestic		
116	....do	....do	E 1	1903	Dug, 3 by 3 foot.	66	22	27	82	Hand			....do		
117	A. D. Keating	....do	F-2		....do	35	31	11	90	....do			....do		
118	L. Sentons	....do	F, G-1		Dug, 6 by 6 foot.	80	46	9	98	Wind			Domestic; stock		
119	L. Wilhelm	Agua de la Centela	G-2		Dug, 3½ by 3½ foot.	48	35	17	160	....do			....do		

Wells in Redondo quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
64	J. Hefflebower	La Ballona	D, E-1	1895	Dug, 3 by 4 foot.	51	25	28	73	Wind		$125.00	Domestic	
65	H. Lehman	do	E-1	1891	Dug, 4 by 4 foot.	40	25	16	120	Hand			do	
66	A. D. Keating	do	E-2		Dug, 3½ by 3½ foot.	25	21	10	130	do			do	
67	do	do	D-2	1903	Bored, 12-inch	24	24	32	76	Artesian	$50.00		Stock	
68	do	do	D-2	1898	Bored, 7-inch	18	18	500		do			do	†1
69	Los Angeles Co	do	E-1		do	60	31	53	70	Wind	60.00	100.00	Roads	
70	John J. Charnock	do	E-1	1882	do	60	28	69	78	Hand	70.00		Domestic; stock	
71	do	do	E-1		do	60	30	38	61	do	40.00		Domestic	
72	M. D. Chavez	do	E-1	1900	Dug, 3 by 3 foot.	51	31	21	90	Wind	20.00	75.00	do	
73	P. Chavez	do	E-1	1895	Dug, 4 by 4 foot.	49	32	21	103	do	20.00	65.00	do	
74	D. I. Russell	do	E-1		do	52	42	15	103	do	20.00	50.00	do	
75	Mrs. L. A. Sanford	do	E-1	1878	do	48	38	13	103	Hand			do	
76	Mrs. Ida Niles	do	F-2		do	23	17	14	80	Wind			do	
77	do	do	E-2		do	23	18	13	86	Hand			Stock	
78	John J. Charnock	do	C-2		Dug, 3½ by 3½ foot.	17	13	10	81	Wind			do	
79	A. D. Keating	do	C-2		Dug, 3 by 3 foot.	17	13	10	79	do	15.00		do	
80	Beach Land Co	Sausal Redondo	D-4		Bored, 12-inch	65	4	256	71		512.00		Domestic	
81	do	do	D-4	1902	do	66	4	268	71	Gas	405.00		do	
82	M. Leidel	La Ballona	F-1	1897	Bored, 7½-inch	35	31	260	65	Wind			Domestic; stock	
83	do	do	F-1	1883	Bored, 7-inch	35	31	30	103	Hand			Not used	
84	Joe Mesmer	do	F-1	1900	Bored, 4-inch	27	23	33	230+	do			Domestic	
85	do	do	F-1	1900	Dug, 5 by 5 foot.	27	22	13		do			do	
86	do	do	F-2		Dug, 4 by 4 foot.	27	21	14	67	do			do	

87	....do	....do	F-2		....do	25	16	15	63	....do				Stock					
88	....do	....do	F-2		....do	23	19	9	60	....do				Domestic					
89	....do	....do	F-2	1901	....do	23	16	10	108	....do				....do					
90	....do	....do	E-2		....do	17	9	25	173	....do	25.00			Stock					
91	R. Machado	....do	E-2		Dug, 3 by 3 foot.	17	10	10	80	....do				Domestic					
92	J. Mesmer	....do	E-2		Dug, 4 by 4 foot.	20	15	10	89	....do				....do					
93	....do	....do	E-2		Bored, 4-inch	16	16		71	Artesian				Stock					1
94	....do	....do	E-3	1902	Bored, 12-inch	15	15	45	72	Gas, artesian				Duck pond					
95	....do	....do	E-3	1902	....do	15	15	92	72	....do				....do					
96	....do	....do	E-3	1902	....do	15		87	72	....do				....do					
97	....do	....do	E-3		....do	15	15	38	72	....do				....do					
98	....do	....do	E-3	1902	....do	15	15	57	72	....do				....do					
99	....do	....do	E-3	1902	Bored, 6½-inch	21	16	24	72	Hand				Domestic					
100	....do	....do	E-2		Dug, 4 by 4 foot.	20	16	9	86	....do				Stock					
101	A. D. Keating	....do	F-1	1902	....do	35	30	8	220+	Wind				....do					
102	Mrs. Ida Nues	....do	F-1	1897	Dug, 3 by 3 foot.	40	35	9	101	Hand				Domestic					
103	Manuel Perez	....do	F-1	1881	....do	44	39	10	106	....do				....do					
104	M. Lugo	....do	F-1	1902	....do	49	43	12	94	....do				....do					
105	C. Peters	....do	F-1		Dug, 3½ by 3½ foot.	48	39	14	115	....do				....do					
106	Joseph Faulk	....do	F-1		Dug, 3 by 3 foot.	49	41	12	96	....do				....do					
107	A. Machado	....do	F-1		....do	40	34	10	94	....do				Stock					
108	B. Machado	....do	F-1		Dug, 3 by 4 foot.	40	36	8	93	Wind				....do					
109	Mrs. Ida Niles	....do	F-1	1902	Dug, 4 by 4 foot.	46	31	17	138	Hand	20.00			Domestic					
110	C. Oliveras	....do	G-1		Dug, 3½ by 3½ foot.	48	36	14	94	....do				....do					
111	....do	....do	G-1	1889	Dug, 2 by 3 foot.	70	36	37	72	....do	35.00			....do					
112	A. Machado	....do	G-1	1885	Dug, 4 by 4 foot.	60	39	23	98	....do				....do					
113	M. Perez	....do	G-1	1903	Bored, 7-inch	100	21	96	76	Wind			65.00	....do					
114	L. Sentons	....do	G-1	1903	Bored, 8-inch	175	19	163	71	....do			75.00	Stock					
115	T. Oliveras estate	....do	E-1	1888	Bored, 7-inch	66	40	35		....do	35.00		75.00	Domestic					
116	....do	....do	E-1	1903	Dug, 3 by 3 foot.	66	22	27	82	Hand				....do					
117	A. D. Keating	....do	F-2		....do	35	31	11	90	....do				....do					
118	L. Sentons	....do	F, G-1		Dug, 6 by 6 foot.	50	46	9	98	Wind				Domestic; stock					
119	L. Wilhelm	Agua de la Centela	G-2		Dug, 3½ by 3½ foot.	48	35	17	100	....do				....do					

Wells in Redondo quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
175	D. Freeman	Sausal Redondo	I-3	1899	Bored, 9½-inch	161	33	191	47	Gas			Domestic; irrigation.	
176	Geo. Love	do	I-3	1902	Bored	160	37	180	57	Wind	$200.00	$100.00	Domestic	
177	P. A. Moore	do	I-3	1897	Bored, 7-inch	155	45	190	46	do	225.00	100.00	Domestic; irrigation.	
178	D. Freeman	do	I-3		do	161	33	160	46	do	200.00		Domestic	
179	Los Angeles and Redondo Rwy. Co.	do	I-2		Bored, 10-inch	175			42	do			Manufacturing	
180	Mr. Burkhart	do	I-2		Bored, 12-inch	160	131			Gas			Irrigation	
181	do	do	I-2		do	160	131			do			do	
182	do	do	I-2		Bored, 7-inch	160	131			do			do	
183	do	do	I-2		Bored, 12-inch	160	131			do			do	
184	Inglewood Water Co.	Sec. 22, T. 2 S., R. 14 W.	I-2		Bored, 7-inch	175			43	do			Not used	
185	do	do	I-2	1899	Bored, 12-inch	175	115	60	43	do	100.00	2,500.00	Domestic; irrigation.	95
186	do	do	I-2		Bored, 7-inch	175			43	do			do	
187	do	do	I-2		Bored, 12-inch	175	115	60	43	do			do	
207	A. Grunwand	Sec. 21, T. 2 S., R. 14 W.	I-2		Bored, 7-inch	202	113	90	46	Wind	100.00	75.00	Domestic	
208	do	do	I-2	1903	do	202	114		46	do			do	
209	A. Saulque	Sec. 22, T. 2 S., R. 14 W.	J-2	1887	do	202	123	90	41	do	100.00	75.00	do	
210	do	do	I-2	1887		211	126	110	43	do	125.00	75.00	do	
211	D. S. Jacobie	do	J-2	1896	Bored, 7-inch	173	123	210	39	Gas	177.00	300.00	Domestic; irrigation.	

148	....do....	....do....	F-6....	1898	....do....	105	3	109	57	....do....	125.00	75.00	....do....	....	
149	Geo. Stimpson	....do....	F-6....	1895	....do....	125	2	257	....	Hand	400.00	....	Domestic	....	
150	Ed. Vall	....do....	F-7....	1898	Bored, 9-inch...	145	5	200	63	Wind	....	....	....do....	....	
151	G. Dagey	....do....	G-7....	1893	Bored, 7-inch...	89	29	175	47	....do....	200.00	100.00	....do....	....	
152	Wiseburn school district.	....do....	G-7....	....	....do....	95	13	93	51	....do....	100.00	65.00	....do....	....	
153	J. S. Vosberg	....do....	H-6....	....	....do....	94	10	117	72	....do....	125.00	75.00	....do....	....	
154	Pomeroy & Harrison	....do....	H-6....	1871	....do....	80	30	300+	49	....do....	....	100.00	Domestic; stock	....	
155	E. D. Neff	....do....	H-5....	1902	Bored, 12-inch..	74	20	185	....	Gas	260.00	2,700.00	Irrigation	....	
156	Frank Dickens	....do....	H-5....	....	Bored, 10-inch..	77	24	200	220	....do....	300.00	2,000.00	....do....	†75	
157	D. Freeman	....do....	H-5....	....	Bored, 7-inch...	85	20	100?	....	Wind	....	....	Domestic	....	
158	Inglewood Water Co.	....do....	H-4....	....	....do....	87	27	50	....	....	55.00	....	Not used	....	
159	W. H. Neher	....do....	H-4....	1903	Bored, 12-inch..	105	28	204	63	Gas	342.90	2,500.00	Irrigation	†50	
161	E. Forney	....do....	H-4....	1895?	Dug, 3 by 2 foot.	110	66	59	54	Wind	60.00	65.00	Domestic	....	
162	Mrs. E. C. Johnson	....do....	H-4....	1898	Bored, 7-inch...	108	38	200	43	....do....	250.00	65.00	....do....	....	
163	H. A. Whistler	....do....	I-4....	1903	Bored, 12-inch..	100	25	195	82	Gas	324.00	265.00	....do....	....	
164	D. Freeman	....do....	I-4....	....	Dug, 3 by 3 foot.	85	37	62	106	Wind	65.00	65.00	....do....	....	
165	Post & Lockhart	Sec. 3, T. 3 S., R. 14 W.	J-5....	....	Bored, 8-inch...	80	10	88	54	....do....	100.00	75.00	Domestic; stock	....	
166	E. W. Sisson	Sausal Redondo	I-5....	1883	Bored, 7-inch...	70	28	185	107	....do....	200.00	75.00	Domestic	....	
167	W. H. Kelso	....do....	I-5....	1893	Bored, 8-inch...	71	30	835	29	....do....	2,200.00	150.00	....do....	....	
168	Post & Lockhart	Sec. 10, T. 3 S., R. 14 W.	I-6....	1903	Bored, 12-inch..	65	23	....	115	Not raised	....	....	Not used	....	
169	....do....	....do....	I-6....	1903	....do....	65	20	....	42	Electric motor	....	....	Irrigation	....	
170	Cochran & Williams	Sec. 15, T. 3 S., R. 14 W.	I-6....	1900	....do....	60	30	368	39	....do....	....	....	....do....	†185	
171	D. H. Griffith	Aguaje de la Centinela.	H-4....	1902	Bored, 10-inch..	117	28	310	48	Wind	480.00	75.00	Domestic	....	
172	J. W. Hoff	....do....	H-4....	1903	Bored, 12-inch..	117	39	220	82	....do....	406.00	100.00	....do....	....	
173	Emmert Stayer	....do....	H-3....	1903	Dug, 3 by 3 foot.	120	35	103	78	....do....	100.00	75.00	....do....	....	
174	W. H. Kelso	Sausal Redondo	I-3....	1899	Bored, 8-inch...	145	25	301	46	Gas	425.00	1,000.00	Domestic; irrigation.	†16	

Wells in Redondo quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
175	D. Freeman	Sausal Redondo	I-3	1899	Bored, 9½-inch	161	33	191	47	Gas			Domestic; irrigation.	
176	Geo. Love	do	I-3	1902	Bored	160	37	180	57	Wind	$200.00	$100.00	Domestic	
177	P. A. Moore	do	I-3	1897	Bored, 7-inch	155	45	190	46	do	225.00	100.00	Domestic; irrigation.	
178	D. Freeman	do	I-3		do	161	33	160	46	do	200.00		Domestic	
179	Los Angeles and Redondo Rwy. Co.	do	I-2		Bored, 10-inch	175			42	do			Manufacturing	
180	Mr. Burkhart	do	I-2		Bored, 12-inch	160	131			Gas			Irrigation	
181	do	do	I-2		do	160	131			do			do	
182	do	do	I-2		Bored, 7-inch	160	131			do			do	
183	do	do	I-2		Bored, 12-inch	160	131			do			do	
184	Inglewood Water Co.	Sec. 22, T. 2 S., R. 14 W.	I-2		Bored, 7-inch	175			43	do			Not used	
185	do	do	I-2	1899	Bored, 12-inch	175	115	60	43	do	100.00	2,500.00	Domestic; irrigation.	
186	do	do	I-2		Bored, 7-inch	175			43	do			do	95
187	do	do	I-2		Bored, 12-inch	175	115	60	43	do			do	
207	A. Grunwand	Sec. 21, T. 2 S., R. 14 W.	I-2		Bored, 7-inch	202	113	90	46	Wind	100.00	75.00	Domestic	
208	do	do	I-2	1903	do	202	114		46	do			do	
209	A. Saulque	Sec. 22, T. 2 S., R. 14 W.	I-2	1887	do	202	123	90	41	do	100.00	75.00	do	
210	do	do	I-2	1887		211	126	110	43	do	125.00	75.00	do	
211	D. S. Jacobie	do	J-2	1896	Bored, 7-inch	173	123	210	39	Gas	177.00	300.00	Domestic; irrigation.	

212	.....do.....	.....do.....	J-2.....	.....	Dug, 3-foot diameter; bored, 7-inch.	175	117	.....	.....	Wind.....	.....	.....	Domestic.....	.....
213	Geo. Goerimann.....	.....do.....	J-2.....	1903	Bored, 7-inch...	185	118	152	43	.....do.....	375.00	125.00	.....do.....	.....
214	John Maybohm.....	.....do.....	J-2.....	1903	.....do.....	170	117	122	43	.....do.....	125.00	75.00	.....do.....	.....
215	Mrs. F. Harsh.....	.....do.....	J-1.....	1901	.....do.....	174	129	245	39	Gas.....	300.00	325.00	Domestic; irrigation.	.....
216	Margaret Nelson.....	.....do.....	J-2.....	1903	.....do.....	160	120	137	82	Wind.....	150.00	50.00	Domestic.....	.....
217	J. F. Nelson.....	.....do.....	J-2.....	1903	.....do.....	160	132	145	42	.....do.....	250.00	65.00	.....do.....	.....
218	Hyde Park school district.	.....do.....	J-2.....	.....	Bored, 6-inch...	160	130	126	42	.....do.....	200.00	100.00	Domestic; roads..	.....
219	F. B. Clark.....	.....do.....	J-2.....	1901	Bored, 14-inch..	162	127	355	.....	Not used.....	.....	.....	Not raised.....	.....
220	W. Nahlinger.....	.....do.....	J-2.....	1901	Bored, 7-inch...	160	120	110	.....	Wind.....	125.00	75.00	Domestic.....	.....
221	Los Angeles Co.....	.....do.....	J-2.....	.....	.....	162	117	51	42	.....do.....	50.00	100.00	Roads.....	.....
222	T. W. Sands.....	.....do.....	J-2.....	1897	Dug, 4 by 4 foot.	165	116	50	52	.....do.....	50.00	75.00	Domestic.....	.....
223	F. U. Norton.....	.....do.....	J-2.....	1896	Dug, 3-foot diameter.	153	130	25	43	.....do.....	25.00	50.00	.....do.....	.....
224	A. Leuzinger.....	Sec. 23, T. 2 S., R. 14 W.	J-2.....	1895	Dug, 4 by 4 foot.	156	128	30	48	.....do.....	30.00	75.00	.....do.....	.....
225	J. J. Leuzinger.....	.....do.....	J-2.....	1902	Bored, 12-inch..	160	130	342	.....	Gas.....	800.00	1,500.00	Irrigation.....	†90
226	.....do.....	Sec. 22, T. 2 S., R. 14 W.	J-2.....	.....	Dug, 4 by 4 foot.	149	129	22	43	Wind.....	25.00	50.00	Domestic.....	.....
227	A. C. Donahue.....	.....do.....	J-2.....	1900	Bored, 7-inch...	165	128	150	43	.....do.....	175.00	100.00	.....do.....	.....
228	C. Lang.....	.....do.....	J-2.....	1887	Dug, 3 by 3 foot.	160	Dry.	30	.....	Hand.....	30.00	.....	.....	.....
229	A. Chapman.....	.....do.....	J-2.....	1891	Dug, 4-foot diameter.	160	Dry.	35	.....	Wind.....	40.00	75.00	Domestic.....	.....
230	Mrs. Routh.....	Sec. 27, T. 2 S., R. 14 W.	J-3.....	1895?	Bored, 7-inch...	200	113	1007	48	.....do.....	125.00	100.00	.....do.....	.....
231	Richard Hoff.....	.....do.....	J-3.....	.....	.....do.....	231	101	150	35	.....do.....	175.00	75.00	.....do.....	.....
232	Mrs. S. O. Mann.....	.....do.....	J-3.....	1889	.....do.....	235	91	160	46	.....do.....	175.00	75.00	.....do.....	.....
233	.....do.....	.....do.....	J-3.....	1889	.....do.....	220	96	153	47	Not raised.....	175.00	.....	Not used.....	.....
234	Inglewood Realty Co.	.....do.....	J-3.....	.....	.....do.....	.....	Dry.	121	.....	.....do.....	135.00	.....	.....do.....	.....
235	F. B. Clark.....	Sec. 23, T. 2 S., R. 14 W.	J-2.....	1888	.....do.....	150	140	256	42	Wind.....	.....	.....	Domestic.....	.....
236	.....do.....	.....do.....	J-2.....	1877	.....do.....	146	143	200	.....	.....do.....	.....	.....	.....do.....	.....
237	.....do.....	.....do.....	J-2.....	1877	.....do.....	150	136	250	.....	Horsepower.....	.....	.....	Stock.....	.....
238	J. T. Joughin.....	Paso de la Tijera..	J-1.....	.....	.....do.....	152	135	75	39	Wind.....	.....	.....	Domestic.....	.....
239	.....do.....	.....do.....	J-1.....	1888	.....do.....	140	139	116	22	Not raised.....	150.00	.....	Not used.....	.....

Wells in Redondo quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
240	A. J. Thornburg	Sec. 24, T. 2 S., R. 14 W.	K-1	1888		140	130	102	43	Wind			Domestic; roads.	
241	Wiesendanger Place	Sec. 23, T. 2 S., R. 14 W.	K-1	1888	Bored, 7-inch	140	132	344	20	Not raised			Not used	
242	Mr. Miller	Sec. 24, T. 2 S., R. 14 W.	K-1		Dug, 3-foot	140	130	60	48	Hand			Domestic	
244	Mrs. Conley	Sec. 25, T. 2 S., R. 14 W.	K-2		Dug, 4 by 4 foot	160	132	33	65	do			do	
245	do	do	K-2		do	145	134	14	67	do			Not used	
246	do	do	K-3	1903	Bored, 12-inch	190	110	666		Not raised			do	
247	John Wagner	Sec. 36, T. 2 S., R. 14 W.	K-3	1889	Bored, 7-inch	190	125	93	43	Wind	$100.00	$75.00	Domestic; stock	
248	Michael Wagner	do	K-3	1886	do	170	116	82	42	do	100.00	75.00	do	
249	Peter Phill	do	L-3	1886	do	160	115	94	43	do	100.00	100.00	Domestic	
250	Mike Mertus	Sec. 35, T. 2 S., R. 14 W.	K-3	1886	do	190	118	76	46	do			do	
251	Will Smith	Sec. 3, T. 3 S., R. 14 W.	J-3		do	80	20	108	57	do	115.00	75.00	do	
252	Post & Lockhart	Sec. 2, T. 3 S., R. 14 W.	J-5		do	85	16	129	36	do	150.00	75.00	do	
253	do	Sec. 10, T. 3 S., R. 14 W.	J-5		do	70	30			do			Not used	
254	do	do	J-5		do	70	30			do				
255	do	Sec. 11, T. 3 S., R. 14 W.	J-6	1895	do	62	32	200	43	do			Domestic	
256	Frank Sparks	Sec. 15, T. 3 S., R. 14 W.	J-6	1893	Dug, 4 by 4 foot	61	31	33	83	do	35.00	75.00	do	
257	E. L. Wade	do	J-7	1897	Dug	60	35	30	171	do	25.00	75.00	do	

258	Post & Lockhart	Sec. 14, T. 3 S., R. 14 W.	K-6		Bored, 4-inch	65	22	61	46	do	50.00	75.00	do	
259	do	Sec. 11, T. 3 S., R. 14 W.	K-5		Bored, 3½-inch	150	38	164	42	do	150.00	75.00	Domestic; stock	
260	J. Reingans	Sec. 2, T. 3 S., R. 14 W.	K-4	1893	Bored, 7-inch	238	92	160	43	do	200.00	100.00	Domestic	
261	Geo. Wagner	Sec. 35, T. 2 S., R. 14 W.	K-4		Bored, 6-inch	200		58			60.00		do	
262	do	Sec. 36, T. 2 S., R. 14 W.	K-4	1891	Bored, 7-inch	200	128	84	66	Wind	100.00	75.00	do	
263	Davison Sisters	Sec. 24, T. 2 S., R. 14 W.	K-2	1873?	do	140	126		46	do		75.00	do	
264	Hermosa Beach Water Co.	Sausal Redondo	G-9	1903	Bored, 10-inch	80	0	502		Gas		9,000.00	do	
265	do	do	F-10		Hydraulic	50		148?						
266	Mr. Cook	do	G-8		Bored, 7-inch	90	14	130	51	Wind	150.00	75.00	Domestic; stock	
267	Manhattan Beach Co.	do	F-8		Bored, 10-inch	85	20	250	84	Gas			Domestic	
268	Mr. Peck	do	E-8		Bored	105		600	84	do			Not used	
269	W. Smith	do	F-9	1892	Bored, 7-inch	150	30	172	53	Wind	200.00	65.00	Domestic	
270	Blanton Duncan estate.	do	F-9		Bored, 8¼-inch	110	26	154		do			do	
271	S. C. Smith	do	F-10	1902	Bored, 7-inch	30		116	43	Gas	165.00		do	
272	Hermosa Beach Water Co.	do	F-10		Bored	25	0	200					Not used	
273	do	do	F-10	1902	do	25	0	140	230+	Gas				
274	Israel Fry	do	F-10	1902	Bored, 7-inch	167	74	150	55	Wind			Domestic	
275	Venable & Claghorn	do	F-10		do	175	89	176	42	do	200.00	100.00	Domestic; stock	
276	W. J. Edwards	San Pedro	G-11	1900	Bored, 5-inch	58		70	53	do	70.00	75.00	do	
277	C. A. Edwards	do	G-8		Bored, 7-inch	95	14	240	57	do			do	
278	Ed Vail	do	H-8	1898	do	75	15	147	49	do	165.00	75.00	do	
279	Mrs. Sarvent	Sausal Redondo	H-8	1883?	Dug, 4 by 4 foot	80	17	70	230+	do	70.00	50.00	Stock	
280	W. C. Miles	do	H-7	1895	Bored, 7-inch	90	38	227	35	do	325.00	175.00	Domestic	
281	C. A. Edwards	do	H-7	1902	Bored, 10-inch	85	25	199	38	Gas			Domestic; irrigation	
282	Post & Lockhart	Sec. 22, T. 3 S., R. 14 W.	J-8	1899	Bored, 4-inch	60	32	154	43	Wind			Domestic; stock	
283	do	do	J-8		Dug, 3 by 3 foot	60	32	35	42	do		75.00	do	
284	Stanley Bates	do	J-8	1903	Bored, 10-inch	62	27		104					

Wells in Redondo quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
285	W. G. Summers	Sec. 27, T. 3 S., R. 14 W.	J-8	1893	Bored, 7-inch	60	30	171	60	Wind	$200.00	$50.00	Domestic	
286	E. Long	Sec. 26, T. 3 S., R. 14 W.	J-8	1901	Bored, 10-inch	61	28	38		do	35.00	75.00	do	
287	J. V. Ford	San Pedro	I-9	1902	Bored, 7-inch	100	10	149	26	do	175.00	75.00	do	
288	Herman Geissler	do	I-9	1903	Bored, 10-inch									
289	Walter Vail	Sausal Redondo	H-8	1890	Bored, 7-inch	73	24	125	37	Wind	135.00	65.00	Stock	
290	do	do	H-9		do	90	23	127	55	do	135.00	75.00	Domestic	
291	J. G. McMorty	Sec. 27, T. 3 S., R. 14 W.	J-9	1888?	Dug, 5 by 5 foot.	50	30	25	28	Hand			do	
292	C. R. Davis	San Pedro	J-9	1903	Bored, 7-inch	48	21	238		Gas	307.00		Domestic; irrigation.	
293	T. O. Dwight	do	J-9	1899	do	46	21	208	43	Steam			Irrigation	60
294	N. Packard	do	K-9	1897	do	48	20	215	45	do	300.00	300.00	do	
295	H. J. Harris	Sec. 26, T. 3 S., R. 14 W.	K-8	1902	Bored	55	27	205	92	Wind				
296	M. G. Rogers	Sec. 23, T. 3 S., R. 14 W.	J-8		do					Gas			Irrigation	
297	do	do	J-8		Bored, 8-inch	75							Not completed	
298	W. C. Smith	do	K-8		Dug, 3 by 3 foot.	56	26	35	220	Wind			Domestic	
299	C. W. Constable	do	K-8	1901	Bored, 7-inch	55	27	53	230+	do			do	
300	W. F. Pope	San Pedro	K-8	1901	Bored, 9½-inch	55	23	217	54	Gas			Irrigation	
301	do	do	K-8	1897	Hydraulic, 2-inch.	55	103	190	54	Wind		65.00	Domestic	
302	H. J. Bleay	Sec. 26, T. 3 S., R. 14 W.	K-8	1902	Bored, 10-inch	55	23	36	134	do			Stock	
303	H. G. Harris	do	K-8		Bored	55	23	220	45	Gas		1,800.00	Irrigation	

304	Arthur Hyon	Sec. 23, T. 3 S., R. 14 W.	K-8	1902	Bored, 7-inch	54	24	215	43	Compressed air	282.75		do	
305	H. C. Feder	San Pedro	E-11	1893	do	60	0	112	38	Wind	128.00	100.00	Domestic	
306	do	do	G-11	1902	Bored, 10-inch	90	0	223	36	Gas	346.00		Irrigation	†5
307	Mrs. John F. Francis	do	H-10	1893	Bored, 7-inch	90	11	175	42	Wind	200.00	125.00	Domestic	
308	Redondo Cemetery	do	H-10	1903	do	125	15	199	35	do	350.00	65.00	Irrigation	
309	Redondo Electric Rwy	do	H-10	1902	Bored, 12-inch	91		280	30	Electricity			Cooling machinery.	
310	W. D. Hammond	do	H-10	1902	Bored, 7-inch	100	2	190	45	Wind	224.00	75.00	Domestic	
311	Mrs. Allen Loomis	do	I-10	1888	do	90	1	140	41	do	160.00		do	
312	Geo. Harsh	do	I-10	1895	do	91	1	174	43	do			do	
313	A. Rochleau	do	I-10		Bored, 10-inch	90	4	223	43	Gas	375.00		Irrigation; domestic.	
314	Paul Wandtke	do	I-9		Bored, 7-inch	86	1	169	42	Wind			Domestic	
315	W. S. Fullerton	do	I-9		do	84	1	150	41	do	175.00		do	
316	Carl Schalk	do	I-9	1888	do	100	17	179	41	do	200.00	75.00	do	
317	W. Sealey	do	I-9	1893	Bored, 6-inch	76	4	108	32	do	125.00	75.00	do	
318	W. S. Fullerton	do	I-10		Bored	92				Gas			Irrigation	
319	J. Rochleau	do	I-10	1902	Bored, 10-inch	93	26	230	30	do			do	12
320	Guy Loomis	do	I-10	1903	do	92	27	250		do			do	15
321	R. O. Hickman	do	I-10	1902	do	87	22	230		Not installed	450.00			
322	Mr. Scott	do	I-10		Bored, 7-inch	95	25	120	46	Wind	135.00	80.00	Domestic	
323	do	do	H-10		do	150	14	190	32	do		65.00	do	
324	T. Biggart	do	J-9	1903	Bored, 4-inch	69	29	227	34	Gas	350.00		Domestic; stock	
325	John Schroeder	do	J-9	1908	Bored, 7-inch	60	23	230	173	Hand	290.00		Domestic	
326	Mrs. Elizabeth Goss	do	J-9	1901	do	60	21	218	38	Wind			do	
327	C. Raphael	do	J-9	1902	Bored, 10-inch	60	21	226	33		300.00		Not used	
328	do	do	J-9	1902	Bored, 7-inch	60	21	220	33	Compressed air	800.00	2,600.00	Irrigation	56
329	Mrs. Isabel Frayer	do	K-9	1896	do	57	26	255	35	Gas	350.00	1,100.00	do	
331	J. Bixby	Los Palos Verdes	G-14		Bored, 8-inch	200?	667	600	173	do	10,000.00		Stock	
332	C. H. Quandt	do	H-12, 13		Bored, 7-inch	100	35	80	46	Wind			do	
333	do	do	H-12, 13		do	100	35	80	38	Gas			Stock; domestic	
334	Doctor Lind estate	do	H-13	1885	Bored, 8-inch	100	30	100	48	Wind	150.00	60.00	do	
335	P. S. Venable	do	I-14	1888	Bored, 7-inch	100		100		do				
336	R. S. Venable	do	I-14	1896	do	140	25	235	77	do	365.00	100.00	Domestic; stock	
337	B. S. Weston	do	I-13	1892	do	100	35	262	42	do	800.00	100.00	Stock; domestic	

Wells in Redondo quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
338	B. S. Weston	Los Palos Verdes.	I-15	1892	Bored, 7-inch	165	30	175	77	Wind, gas	$375.00	$125.00	Domestic	
339	do	do	I-15	1901	do	165	30	470	77	Gas	900.00	410.00	do	†4
340	do	do	J-13	1898	do	100	35	223	42	Wind	511.00	100.00	do	
341	do	do	J-14	1892	Bored, 5-inch	100	35	170	43	do	350.00	100.00	Domestic; stock	
342	Mrs. Means	do	I-13	1895	Bored, 7-inch	100	30	189		Gas	210.00	160.00	Stock	5
343	Mrs. Minnie Leich	do	I-13	1886	do	100	30	175	38	Wind	203.00	100.00	Domestic; stock	2½
344	H. J. McNally	do	I-13	1889	do	110	27	113		do			Not used	
345	do	do	I-13	1901	do	105	29	265	35	Gas	384.00	775.00	Stock; domestic; irrigation.	35
346	G. W. Vaness	do	I-13	1889	do	100	30	114	44	Wind	120.00	75.00	Stock; domestic	
347	Doctor De Lamo	San Pedro	I-12	1892	do	110	35	275	36	do		100.00	Domestic; stock	
348	E. Keffler	Los Palos Verdes.	K-13	1889	do	100	49	78	73	do		75.00	Stock	
349	G. A. March	San Pedro	K-13	1888	Bored, 6-inch	90	50	105	61	do	110.00	55.00	Domestic; stock	
350	Joseph Lucas	do	K-13		Bored, 7-inch	90	40	80	58	do			Domestic	
351	Fred Bluemle	do	L-13	1897	do	80	42	290	26	do	433.00	100.00	Domestic; stock	
353	Oliver McCoy	Los Palos Verdes.	L-14	1901	Bored, 10-inch	75	36	285	25	do	400.00	125.00	Stock; domestic	
354	H. Dumke	do	L-14	1901	Bored, 7-inch	75		388	34	do	425.00	75.00		
355	Mr. Nearbaum	do	K-14		do	80		400?	22	do			Stock	
356	F. West	San Pedro	M-14	1900	Dug, 4 by 4 foot	80	48	5	61	Hand			do	
357	Baptiste Lave	do	M-13		Bored, 7-inch	89	23	35	102	Wind			Stock; domestic	
358	Mrs. Jargins	Los Palos Verdes.	L-14	1888	do	65		450	26	do		60.00	do	
360	Palos Verdes Winery	do	L-14	1884	Dug, 3-foot diameter.	80	32	25	195	do			Irrigation; winery	
361	do	do	L-14	1895	Dug, 4-foot diameter.	65	34	49	193	do	80.00	75.00	Winery	

383	Oscar McCoy	do	M-15	1897	Dug, 4 by 4 foot.	30	11	26	67	do	50.00	100.00	Stock; domestic; irrigation.		
384	Andrew Hobland	do	L, M-15	1902	do	30	11	46	91	do		75.00	Not used		
385	Geo. Jorgenson	do	L-15	1898	Dug, 2 by 4 foot.	25	19	18	71	Hand			Domestic; stock		
386	Neil Khirkaby	do	L-15	1899	Dug, 4 by 4 foot.	25	8	25	61	Wind		40.00	Domestic		
387	Geo. Bixby	do	L-16	1902	Dug, 3 by 8 foot.	25	23			do	150.00		Stock		
388	do	do	L-15	1900	Dug, 4 by 4 foot.	50?	36	16	55	do	35.00	65.00	Domestic; stock		
389	Mr. Nearbaum	do	J-15	1895	Bored, 7-inch	175		122		Not raised			Not used		
370	Mr. Burkhardt	do	L-17		Bored, 10-inch	40	10	300?	145	Wind			Domestic; stock		
371	do	do	L-17		Bored, 7-inch	25	25		161	Artesian			Stock		
372	Roman Sepulveda	do	L-17		Dug, 25-foot diameter.?	25	12	16	81	Steam			Domestic		
373	do	do	L-17	1900	Dug, 17-foot diameter.?	25	12	16	86	do			do		†9
374	do	do	L-17	1901	do	20	12	10	65	do			do		
375	do	do	L-17	1902	Dug, 10-foot diameter.	25	15	13	67	do			do		
376	J. W. Sepulveda	do	L-17		do	20			75						
377	W. O Sepulveda	do	L-17	1897	Dug, 4 by 4 foot.	20	10	12	230+	Hand	30.00		Fire		
379	De Lamo & Humphrey	San Pedro	K-11	1885	Dug, 3½ by 3½ foot.	50	13	37	140	Wind			Domestic; stock		
381	J. H. Adelmeyer	do	K-10	1891	Dug, 4-foot diameter, 40 feet; bored, 7-inch, 25 feet.	60	20	65	75	do		100.00	Domestic		
382	J. A. Cameron	do	K-10	1902	Bored, 12-inch	60	30	45	81	Hand	22.00	45.00	Domestic; stock		
383	Mr. Gilmore	do	K-10	1902	do	60	18	48		Wind	24.00		Domestic		
384	Mrs. F. A. Corwin	do	K-10	1903	Hydraulic, 4-inch.	55	19	163	28	Hand	125.00	25.00	Domestic; stock		
385	G. E. Brooks	do	K-10	1902	Bored, 12-inch	60	23	45	65	do	22.50	15.00	do		
386	Moneta Water Co	do	K-10		Dug, 8 by 8 foot.	60	15	500	33	Steam		185.00	Irrigation		†30
387	do	do	K-10		Dug, 8 by 8 foot, 45 feet; bored balance.	60	15	200	33	do			do		†30
388	do	do	K-10		do	60	15	200	33	do			do		†30
389	C. W. Stephenson	do	J-10	1903	Bored, 10-inch	65	23	52	145	Hand	27.00	23.00	Domestic		
390	J. M. Dunn	do	J-10	1901	Bored, 8-inch	65	20	209	34	Gas	275.00	860.00	Domestic; irrigation.		†30
391	J. L. Dunn	do	K-9	1900	Dug, 5 by 5 foot.	58	34	29	25	Wind	30.00	25.00	Domestic		

Wells in Redondo quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
392	F. E. Sanders	San Pedro	K-10	1903	Bored, 12-inch	60	22	55	120	Hand	$27.50	$15.00	Domestic	.....
393	T. Holloway	do	K-10	1903	do	60	25	40	230+	Wind	20.00	40.00	Domestic; stock	.....
394	Mrs. Lucy F. Richardson.	do	K-10	1903	do	55	23	43	193	do	21.00	.....	Domestic	.....
395	J. T. Blackburn	do	K-10	1903	do	55	25	42	156	Hand	21.00	.....	do	.....
396	H. A. Johnson	do	K-9	1875	Bored, 7-inch	45	37	185	35	do	225.00	.....	Domestic; stock	.....
397	do	do	K-9	.....	Bored, 12-inch	55	20	214	.....	Gas	257.00	.....	Irrigation	†125
398	M. B. Bynum	do	K-9	1903	Bored, 10-inch	70	50	35	30	Wind	12.25	20.00	Stock	.....
399	F. H. Fraser	do	K-9	1903	Bored, 12-inch	25	13	26	230+	do	13.00	.....	Domestic; stock	.....
400	B. A. Moore	do	K-9	1908	Hydraulic, 4-inch, 40 feet; 2-inch, 105 feet.	30	10	145	24	Hand	90.00	7.00	Stock	.....
401	do	do	K-9	1900	Bored, 12-inch	35	15	31	117	do	.....	7.00	do	.....
402	J. T. Limville	do	K-9	1896	.....	35	15	150	33	Wind	75.00	.....	Domestic; irrigation; stock.	.....
403	R. Mikkelson	do	K-9	1898	Bored, 7-inch	35	17	170	37	Wind, gas	170.00	250.00	Domestic; irrigation.	†35
404	do	do	K-9	.....	Dug, 4 by 4 foot	35	17	40	106	Hand	.....	.....	Stock	.....
405	P. D. Armstrong	do	K-9	1894	Bored, 7-inch	35	15	190	36	Gas	.....	450.00	Domestic; irrigation.	.....
406	A. B. Caldwell	do	K-9	1897	do	35	15	163	36	Wind	200.00	60.00	Domestic; stock	.....
407	Fred Hant	do	K-9	.....	Bored, 12-inch	40	18	38	20	do	.....	.....	Domestic	.....
408	A. B. Caldwell	do	K-9	1900	Bored, 7-inch	40	20	206	33	Gas	300.00	700.00	Irrigation	†30
409	Chas. Webb	do	K-9	1901	do	40	20	200	37	Wind	250.00	60.00	Domestic; irrigation; stock.	.....
410	R. H. Hudson	do	K-9	1902	Bored, 10-inch	40	21	26	230+	do	13.00	.....	Domestic; stock	.....
411	Mr. Pine	do	K-9	1903	Bored, 12-inch	40	22	25	169	Hand	12.00	.....	Domestic	.....

412	W. S. Meyers	do	K-9		Bored, 7-inch	40	21	224	43	Gas		725.00	Domestic; irrigation.	†75
413	Monita Canning Co.	do	K-9	1898	do	45	14	224	34	Steam			Cannery	†150
414	T. Cooper	do	K-9	1903	Bored, 12-inch	32	20	25	230+	Hand	13.00		Stock	
415	do	do	K-9	1901	do	40	20	36	230+	Wind	18.00	16.00	Irrigation; stock	
416	Monita school district	do	K-9	1896	Bored, 4-inch	48			34	do			Domestic	
417	W. H. Martin	do	K-9	1903	Dug, 4 by 4 foot.	45	21	26	230+	Gas	150.00	50.00	Stock	
418	T. O. Dwight	do	K-9		do	45	19	27	230+	Hand			Not used	
419	G. A. King	do	J-9	1902	Dug, 3 by 3 foot.	45	27	20	230+	do	10.00		Domestic	
420	W. A. Cameron	do	J-9	1892	Dug, 3½ by 3½ foot.	55	33	25	230+	do	25.00	5.00	Stock	
421	M. W. Raibley	do	K-9	1902	Bored, 7-inch	45	23	108	61	Wind	235.00	60.00	Domestic; stock	
422	Geo. H. Watkinson	do	K-9	1901	Bored, 12-inch	50	34	26	230+	Hand	13.00	10.00	do	
423	C. F. Bayha	do	K-9	1902	do	55	18	40	230+	Wind	20.00	35.00	Irrigation; stock	
424	H. P. Palmer	do	K-9	1893	Dug, 5-foot diameter.	55	25	32	57	Hand			Stock	
425	A. A. Whaley	do	K-9		Bored, 12-inch	45	17	40	145	Wind		125.00	Domestic	
426	do	do	K-9	1895	Dug, 4 by 4 foot.	50	25	26	127	Hand			Not used	
427	R. H. Diltz	do	K-9	1900	Bored, 12-inch	50	29	28	123	Wind	16.00	60.00	Domestic; stock	
428	M. T. Sprague	do	K-9	1901	do	55	33	38	119	do			Domestic; irrigation; stock.	
429	J. D. Beard	do	K-9	1902	Bored, 7-inch	55	25	134	111	do	140.00	200.00	Domestic; irrigation.	
430	Mr. Champaign	do	K-9	1900	Bored, 12-inch	55	35	37	168	do	17.00	17.00	Not used	
431	Chas. Stebbins	do	K-9	1895	Dug, 5-foot diameter.	53	32	26	104	do			Domestic; stock	
432	H. Terrel	do	K-8	1902	Dug	53	32	25	115	Hand	25.00	2.50	do	
433	W. J. Lembke	do	K-8	1903	Bored, 4-inch	54	32	173	34	Wind	138.40	46.50	Stock	
434	Chas. Winberner	do	K-8		do	55		180						
435	Max Manty	do	K-8	1901	Bored, 12-inch	60	38	40	168	Wind	30.00	60.00	Domestic; stock	
436	B. T. Hayden	do	K-9	1896	Dug, 3½ by 3½ foot.	50	29	25	173	Hand	25.00		Not used	
437	A. W. Dickenson	Sec. 23, T. 3 S., R. 14 W.	K-8	1899	Bored, 8-inch	60	25	230	46	Gas	250.00	825.00	Irrigation	†90
438	Jean Lagier	Sec. 24, T. 3 S., R. 14 W.	K-8	1898	Bored, 7-inch	60		147	42	Wind			Domestic; irrigation; stock.	
439	Mr. Roberts	Sec. 23, T. 3 S., R. 14 W.	K-8	1899	Dug, 4 by 4 foot.	60	27	36	173	do			Domestic; stock	

Wells in Redondo quadrangle—Continued.

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440	O. S. Gorham	Sec. 24, T. 3 S., R. 14 W.	K-8	1893	Dug, 4 by 4 foot.	60	33	30	38	Wind		$60.00	Domestic; stock.	
441	do	do	K-8	1903	Hydraulic, 4½-inch.	60	30	355		Gas	$300.00	1,100.00	Irrigation	†40
442	Geo. O. Lampher	do	K-8	1902	Bored, 10-inch	60	30	43	102	Hand			Domestic; stock.	
443	J. T. Dunn	do	L-8	1901	Bored, 8-inch	60	28	207	86	Compressed air	275.00	1,400.00	Irrigation	†80
444	do	do	L-8	1883	Dug, 3 by 3 foot.	55	30	28	77	Wind	30.00	125.00	Domestic	
445	do	do	L-8	1898	Bored, 10-inch	60	30	199	78	Compressed air	270.00		Stock	†10
446	A. L. Beem	do	L-8	1888	Bored, 4-inch	65	30	140	46	Wind			Domestic; stock.	†5
447	do	do	L-8	1897	Bored, 7-inch	65	30	206	46	Steam			Irrigation.	†65
448	Mrs. Kate Drews	San Pedro	L-8	1893	do	60	27	218	88	Gas	250.00	900.00	Domestic; irrigation.	†30
449	R. J. Rogers	Sec. 24, T. 3 S., R. 14 W.	K-8	1901	do	60	30	197	46	Compressed air	280.00	1,050.00	Domestic, irrigation; stock.	†30
450	do	do	K-8	1896	Hydraulic, 2½-inch.	60	30	187		Not raised	87.00		Not used	
451	G. N. Young	San Pedro	K-8	1903	Bored, 6-inch	60	30	205	40	Hand	180.00	12.00	Domestic; stock.	
452	John Osborne	do	L-8		Bored, 2-inch	60	30	180	39	Wind			do	
453	H. R. Parsons	do	L-8	1898	Bored, 4-inch, 20 feet; bored, 2-inch, 158 feet.	60	30	178	49	do	72.00	80.00	do	
454	R. M. Klingensmith	do	K-8	1901	Bored, 10-inch	60	30	225	55	Gas	600.00	1,400.00	Domestic; irrigation; stock.	†60
455	H. E. Williams	do	K-8	1902	do	60	34	224	46	do	304.00	880.00	Irrigation	
456	Tom Frost	do	K-8	1892	Dug	60	26	31	91	Wind		60.00	Domestic; irrigation; stock.	
457	H. T. Perley	do	L-8	1895	Bored, 7-inch	60	30	208	38	do	190.00	110.00	Domestic; stock.	

458	C. Sebelius	do	L-8	1901	Bored, 10-inch	55	28	240	37	Compressed air	491.00	1,050.00	Domestic; irrigation.	†35
459	Strawberry Park Water Co.	Sec. 24, T. 3 S., R. 14 W.	L-8	1903	Bored, 12-inch	60	28	250	182	Gas			Irrigation	
460	do	do	L-8	1903	do	60	28	225	182	do			do	
461	J. L. Griffin	San Pedro	L-8	1896	Bored, 10-inch	60	30	268	123	Steam	400.00	1,200.00	Irrigation; stock	†125
462	O. S. Graham	do	L-8	1898	Bored, 7-inch	55	33	200	91	Gas	238.00	550.00	Irrigation	
463	Geo. M. Michell	do	L-8	1893	do	55	30	183	42	Wind	125.00	100.00	Domestic; stock	
464	A. A. Cary	do	L-8	1903	Hydraulic, 6-inch.	50	30	194	33	Gas	193.00		Domestic; irrigation.	
465	W. M. Gray	do	L-8	1895	Bored, 7-inch	50	32	225	38	do	300.00	1,400.00	do	
466	Los Angeles Company	do	L-9		do	50	26	61	65	Hand			Domestic	
467	J. H. McCartney	do	K, L-9	1902	Bored, 6-inch	50			36	Wind	90.00	75.00	do	
468	Mr. Clark	do	K-8, 9		Bored, 8-inch	52	26	177	50	Hand			do	
469	E. M. Hicks	do	K-8	1896	Dug, 5 by 5 foot	52	30	25	140	Wind		65.00	Stock	
470	J. A. Burns	do	K-8	1894	Dug, 4 by 4 foot	52	31	24	150	do	26.00	65.00	do	
471	John J. Dean	do	K-9	1902	Bored, 10-inch	50	30	249	36	Wind, gas	400.00	650.00	Domestic; irrigation; stock.	†16
472	B. T. Hayden	do	K-9	1893	Bored, 12-inch	52	32	25	120	Wind	20.00	40.00	Domestic; stock	
473	F. W. Fitzpatrick	do	K-9	1900	do	52	29	30	144	Hand	15.00	5.00	Stock	
474	W. N. Worrell	do	K-9	1903	Bored, 7-inch	50	25	236	50	Gas		500.00	Domestic; irrigation.	†15
475	Will Kempson	do	K-9	1901	Bored, 2-inch	50	32		140	Hand			Domestic	
476	John Elsey	do	K-9	1897	Dug, 4 by 4 foot	51	32	23	123	Wind, hand		45.00	Domestic; stock	
477	W. J. O'Brien	do	K-9	1901	Bored, 12-inch	49	27	35	135	Hand			Domestic	
478	Geo. Burton	do	K-9	1898	Dug, 4 by 4 foot	49	30	23	120	do			do	
479	T. Stayton	do	K-9	1899	Dug, 5-foot diameter	50	32	22	135	Wind	22.00	120.00	Domestic; stock	
480	J. E. Longacre	do	K-9	1897	Dug, 4 by 4 foot			24	137	Hand	25.00	3.00	do	
481	Mrs. M. A. Wells	do	K-9	1896	do	45	26	22	128	Wind		30.00	Domestic; irrigation.	
482	O. W. Kendrick	do	K-9	1903	Bored, 12-inch	38	20	27	135	do	15.00	15.00	Irrigation	
483	H. H. Luckensmeyer	do	K-9		do	45	27	30		Hand			Not used	
484	Edward Larson	do	K-9	1903	do	50	32	30	173	do	15.00		Domestic	
485	H. A. Richards	do	K-9	1903	Bored, 10-inch	38	24	30	137	Wind			do	
486	R. S. Moore	do	K-9	1902	do	38	20	40	120	Hand	20.00		do	
487	D. W. Jackson	do	K, L-9	1901	do	38	20	220	46	Gas		675.00	Irrigation	†70

Wells in Redondo quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
488	W. McCune	San Pedro	L-9		Dug, 4 by 4 foot.	38	20	22	173	Wind			Stock	
489	Pedro Shapro	do	L-9	1898	Bored, 4-inch	38	−2	110?	41	do	$200.00	$50.00	Domestic; stock	
490	A. N. Heffner	do	L-9	1900	Bored, 4-inch, 40 feet; bored, 2-inch, 151 feet.	38	21	191	34	do	100.00	170.00	do	
491	J. A. Lakey	do	L-9	1898	Bored, 7-inch	38	20	235	60	Steam	325.00	1,300.00	Irrigation	†90
492	W. Bryant	do	L-9	1904		43			42	Gas			do	
493	C. E. Wallin	do	L-9	1895	Bored, 4-inch	43	30	28	83	Wind	75.00	105.00	Stock	
494	Jessie Linkletter	do	L-9	1901	do	38	18	150	44	do	120.00	150.00	Domestic	
495	L. Merrill	do	L-9	1898	Dug	38	24	18	106	Hand			Domestic; stock	
496	N. E. Coweles	do	L-9	1902	Bored, 7-inch	38	22	205	37	Gas		550.00	Domestic; irrigation.	†45
497	G. G. Glouner	do	M-9		Dug, 5-foot diameter.	30	16	20	60	Wind			Domestic; stock	
498	Geo. Bones	do	M-9		Bored, 7-inch	38	20	200		do	300.00	75.00	Irrigation	
499	J. Edwin	do	M-9	1900	Dug, 8 by 8 foot.	32	16	35	92	do			Domestic; stock	
500	do	do	M-9	1900	Dug, 12 by 12 foot.	32	16	37	73	Wind, gas			Irrigation	22
501	Mrs. S. J. Barnum	do	M-9	1896	Dug, 5 by 12 foot	35	20	22	102	Wind		75.00	Domestic; stock	
502	Mrs. Alice Champlin	do	M-9		Dug, 4 by 6 foot.	35	21	22	91	do			Not used	
503	J. A James	do	M-9	1899	Dug, 5 by 10 foot	35	21	22	69	do		100.00	Domestic; irrigation; stock.	
504	H. Bristol	do	M-9	1898	Dug, 4 by 4 foot.	30	16	16	82	do		65.00	Domestic; irrigation.	
505	do	do	M-9	1900	Dug, 4 by 6 foot.	35	19	24	92	do	80.00		Irrigation	
506	do	do	M-9	1897	Dug, 3 by 5 foot.	35	20	18	91	do			do	
		do	M-9	1903	Dug, 4 by 6 foot.	35	20	25	109	Gas	120.00	300.00	do	†10

508	Sam Jackson	do	M-9	1903	Dug, 4 by 4 foot.	35	17	31	92	do		328.00	Domestic; irrigation.
509	W. F. Calderwood	do	M-9	1892	do	30	17	14	104	Hand			Not used.
510	do	do	M-9	1897	do	30	18	17	92	Wind			Domestic; stock.
511	B. W. Barnes	do	M-9	1901	Bored, 7-inch	35	16	250	71	do		140.00	Domestic.
512	Irving Baxter	do	M-9		Dug, 4 by 4 foot.	30	14	22	91	do			do.
513	John H. Mackey	do	L-10	1902	Dug	25	7	28	79	do	35.00	165.00	Domestic; stock.
515	A. Schultz	do	L-10	1902	Dug, 4 by 4 foot.	20	1	38	57	do			do.
516	W. L. Kellog	do	M-9	1891	Bored, 6-inch	35	12	16	128	Hand			Domestic.
517	C. Houser	do	M-9		Bored, 5-inch	35		38	117	Wind			Domestic; stock.
518	R. Birt	do	M-9	1894	Dug, 4 by 4 foot.	30	16	23	109	do	75.00	114.00	Domestic; irrigation; stock.
519	do	do	M-9	1893	Bored, 7-inch	38	24	210	106	do	400.00	80.00	Irrigation.
520	D. Cross	do	M-9		Dug, 4 by 4 foot.	40			106	Hand			Stock.
521	Mr. Wickstrom	do	M-9		Dug	35	21	15	101	Wind			do.
522	J. S. Youmans	do	M-9	1902	Dug, 5 by 5 foot.	30	9	25	115	Gas		300.00	Domestic; irrigation; stock.
523	John Blick	do	M-9	1900	Dug, 8 by 10 foot	35	23	15	96	Wind, horsepower		190.00	Domestic; stock.
524	Mrs. Morris	do	M-9	1901	Dug, 3-foot diameter, 7 feet; bored, 10-inch, 18 feet.	30		25	177	Wind			Domestic.
525	John M. Glass	do	M-10		Dug, 4 by 4 foot.	30	13	22	103	Wind, hand			Domestic; irrigation; stock.
526	do	do	M-10	1902	Bored, 7-inch	30	26	540		Not raised	1,200.00		Not used.
527	J. H. Bush	do	M-10	1903	Bored, 12-inch	30	16	30	127	Hand	10.00	5.00	Domestic.
528	E. A. Turner	do	M-10		Dug, 30-inch diameter.	20	20	14	117	Gas	50.00	500.00	Irrigation.
529	do	do	M-10	1903	Bored, 8-inch	28	16	20	118	Hand	2.00	3.00	Domestic.
530	A. E. Elliott	do	M-10		Dug, 4 by 4 foot.	28	13	19	103	Wind			do.
531	do	do	M-10		do	28	17	21	96	do			Stock.
532	Chas. Turnbaugh	do	M-9	1903	Bored, 2-inch	30	20	25	78	Hand			do.
533	Geo. Stiman	do	M-9	1902	Bored, 5-inch	28		60	75	do	23.00		Domestic.
534	B. W. Barnes	do	M-9	1892	Dug, 3 by 3 foot.	30	15	18		Wind	35.00	75.00	Domestic; stock.
535	do	do	M-9	1899	Dug, 4 by 4 foot.	30	9	27	130	do	50.00	120.00	Irrigation.
536	do	do	M-9	1895	Dug, 4 by 5 foot.	40	21	22	151	do	50.00	75.00	do.
537	D. Cross	do	M-9		Dug, 4 by 8 foot.	35	18	17	150	do			Not used.
538	A. O. Whaley	do	M-9	1893	Dug, 4 by 4 foot.	40	25	20	144	do	55.00	100.00	Domestic; stock.

Wells in Redondo quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
539	G. H. Norton	San Pedro	M-9	1895	Dug, 4 by 4 foot.	45	25	24	128	Wind	$60.00	$100.00	Irrigation	
540	do	do	M-9	1892	do	40	25	22	157	Hand	50.00	15.00	Domestic	
541	do	do	M-9	1893	do	45	27	22	177	Wind	60.00	100.00	Irrigation	
542	A. O. Whaley	do	M-9	1894	do	45	26	22	230+	do	55.00	75.00	do	
543	John Stalker	do	M-9		do	40	25	35	132	do			Domestic	
544	John Weber	do	M-9	1895	Dug, 6 by 12 foot	45	22	24	60	Hand		2.50	Not used	
545	R. D. Dow	do	M-8	1894	Bored, 7-inch	45	26	214	115	Steam	250.00	600.00	Domestic; irrigation.	
546	L. H. West	do	M-9	1882	do	45	21	223	104	Gas	400.00	800.00	Domestic; irrigation; stock.	
547	B. E. Jones	do	M-8	1899	do	45	15	227	40	do	370.00	1,050.00	do	
548	do	do	M-8	1893	Dug, 5 by 5 foot.	45	25	28	167	Wind		75.00	Domestic; stock.	
549	John Carden	do	M-8	1897	Bored, 7-inch	50	27	225	44	Gas	275.00	525.00	Domestic; irrigation; stock.	
550	C. N. Bassett	do	M-8		do	85	45	190	47	Wind	230.00		Domestic; stock.	
551	A. B. Moore	do	M-8	1903	Bored, 10-inch	95	35	70	103	do	27.00	35.00	do	
552	Geo. Nichols	do	N-8		Bored, 7-inch	105			42	do			do	
553	C. N. Bassett	do	N-8	1902	Bored, 10-inch	100	75	190	41	Gas		1,700.00	Irrigation	
554	Gardena Water Co	do	N-8	1900	do	85	75	184	43	do			Domestic	
555	do	do	N-8		Bored, 7-inch	85		184	42	do	200.00		do	
556	do	do	N-8		do	85			42	do			do	
557	do	do	N-8		do	85			42	do			do	
558	Duncan Co	do	N-8	1897	Bored, 9¾-inch	80	75	196	39	do	300.00	1,600.00	Irrigation	†130
561	C. F. Rosecrans	Sec. 19, T. 3 S., R. 13 W.	L-7	1903	Hydraulic, 6-inch.	75	26	203	43	Compressed air	226.00	500.00	do	
562	do	do	L-7	1896	Dug	75	50	40	91	do			Domestic	

563	Strawberry Park Land Co.	Sec. 13, T. 3 S., R. 14 W.	L-7	1887	Dug, 6 by 6 foot.	60	36	28	157	....do	500.00		Domestic; stock	
564	G. Nyberg	San Pedro	M-8		Bored, 7-inch	70	40	240		....do	308.00		....do	
565	J. M. Low	....do	M-8	1899?	Dug, 3 by 3 foot.	55	39	17	126	Hand			Domestic	
566	Robert Westcott	....do	M,N-8	1903	Hydraulic, 4-inch, 60 feet; hydraulic, 2-inch, 110 feet.	75	35	170	38	Wind	100.00	75.00	Domestic; stock	
567	J. M. Carter	....do	N-9	1900	Hydraulic, 3-inch.	55	37	467	28	....do			....do	
568	....do	....do	N-9		Bored, 7-inch	45	19	61	74	....do	75.00		Stock	
569	Mr. Thomas	....do	M-9,10	1901	Bored, 3-inch	25	13	338	29	....do			Domestic; stock	
570	....do	....do	M-9		Dug, 4 by 4 foot.	25	21	6	157	Hand			Not used	
571	....do	....do	M-9	1903	Bored, 5½-inch	15	15	305	31	Artesian			Stock	
572	....do	....do	M-9		Dug, 6 by 6 foot.	20	21	12	64	Hand			Not used	
573	John Commings	....do	M,N-10		Bored, 7-inch	50			33	Wind			Stock	
574	C. N. Haskins	....do	N-8	1874	....do	75	65	140	42	....do		165.00	....do	
575	Mrs. F. Murphy	....do	N-9	1899	....do	75	63	350	33	Gas		1,000.00	Domestic; irrigation	†40
576	....do	....do	N-9	1896	Hydraulic, 2-inch.	75	65	350		Not raised			Not used	
577	....do	....do	N-9	1898	Bored, 7-inch	75	75	135		Hand			....do	
578	....do	....do	N-9	1891	....do	75	75	190		Wind		125.00	Stock	
579	....do	....do	N-9	1903	Hydraulic, 4-inch.	75	71	111		Gas	109.00		Domestic; stock	
580	E. C. Haskins	....do	N-8	1883	Bored, 9½-inch	75	53	154	44	....do	250.00	900.00	Irrigation	†75
583	W. R. Steele	....do	N-8	1883	Bored, 6-inch	105	75	175	40	Wind			Domestic; irrigation; stock.	
584	P. Paradis	....do	N-8		Dug, 3½ by 3½ foot.	99	75	26	98	....do			Not used	
585	J. E. Paradis	....do	N-8	1880?	Bored, 7-inch	99	82	188	40	Gas		1,100.00	Domestic; irrigation; stock.	†99
586	Enterprise school district.	....do	N-8		....do	105			38	Wind			Domestic	
587	H. C. Kelsea	....do	N-7	1880	....do	100	85	198	44	Gas		900.00	Domestic; irrigation.	†40
588	Samuel Flick	....do	N-7	1895	....do	100	85	200	38	Wind			Domestic; stock	
589	Mrs. Minnie Lossing	....do	N-7	1891	....do	100	80	197	39	Gas			Domestic; irrigation; stock.	

Wells in Redondo quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
590	P. Commeree	Tajanta	N-7	1899	Bored, 7-inch	90	80	200	36	Gas	$200.00	$700.00	Irrigation	†40
591	Wm. Falkner	do	N-7	1899	Bored, 9½-inch	90	80	250	37	Gas, wind	600.00	1,400.00	Irrigation; stock	†150
592	C. I. Falkner	do	N-7	1899	Bored, 3-inch	100	90	131	42	Wind	60.00	125.00	Stock	
593	Mr. Sooner	Sec. 16, T. 3 S., R. 13 W.	N-7		Dug, 5 foot diameter.	105	70	37	56	do			Domestic	
594	J. Henninger	Sec. 17, T. 3 S., R. 13 W.	N-7	1903	Bored 4-inch, 50 feet; bored, 2-inch, 86 feet.	110	75	136	42	do	85.00	50.00	Domestic; stock	
595	Edward Flick	do	N-7	1890	Dug, 4-foot diameter.	115	78	38	68	do	20.00	30.00	do	
596	C. Hellum	do	N-7	1888	Dug	120	83	39	51	do			do	
597	Shellenberger, Anderson & Park.	San Pedro	N-7	1899	Bored, 10-inch	107	70	193	41	Gas	280.00	815.00	Domestic; irrigation.	†50
598	Geo. Nichols	do	N-7		Dug, 4 by 4 foot.	120	80	58	39	Not raised			Not used	
599	B. H. Muller	Sec. 17, T. 3 S., R. 14 W.	M-7	1897	Bored, 6-inch	120	90	160	38	Gas			Domestic; stock	†5
600	Geo. W. Gaines	do	M-7		do	125			40	Wind			do	
601	Edmund Locke	Sec. 18, T. 3 S., R. 14 W.	L-7	1901	Bored, 7-inch	100	35	250	38	Gas		650.00	Domestic; irrigation; stock.	
602	H. L. Gordon	San Pedro	M-8	1894?	Bored, 4-inch	115	33	208	41	do			Domestic; irrigation.	
604	G. R. Brown	Sec. 16, T. 3 S., R. 13 W.	N-7	1888	Bored, 7-inch	105		196	40	Wind			Domestic; stock	
605	Flick & Hellum	Sec. 17, T. 3 S., R. 13 W.	N-7	1894	do	115	80	198	41	Gas	300.00	600.00	Irrigation; stock	†35
606	G. D. Lee	Tajanta	N-7	1903	Bored, 2-inch	100	91	167	41	Hand	90.00	15.00	Domestic; stock	
607	[illegible]	do	N-7	1901	do	100			41	Wind, hand	100.00	145.00	Domestic; irrigation; stock.	

609	G. F. Brinkernon	do	N-6	1900	Bored, 10-inch	100	100	300		Not raised	535.00		Not used	
610	do	do	N-6	1895	Dug, 4 by 4 foot	100	90	14	62	Wind		100.00		
611	A. L. Davenport	do	N-5	1892	Bored, 2-inch	105	105	300	38	Artesian			Domestic; stock	
612	Castruccio & Vala	Sec. 8, T. 3 S., R. 13 W.	N-5	1888	Bored, 7-inch	110	106	250	42	Hand			Domestic	
613	S. L. Wright	do	N-5	1894	Bored, 9-inch (2)	114	106	238		Gas	1,200.00	1,000.00	Irrigation	†40
614	do	do	N-5	1902	Bored, 12-inch	15	97	550	39	do	1,250.00	1,800.00	Domestic; irrigation.	117
615	do	Sec. 5, T. 3 S., R. 13 W.	N-5	1899	Bored, 9-inch	120	116	300	44	do	600.00	700.00	Irrigation	†50
616	do	do	N-5	1900	Hydraulic, 2-inch	120	13	250	41	Wind	175.00	150.00	Domestic	
617	Mr. Glass	Sec. 8, T. 3 S., R. 13 W.	N-6	1901	Bored, 12-inch	115	98	500	45	Gas	1,250.00		Not used	
618	N. Kirst	Sec. 32, T. 2 S., R. 13 W.	N-4	1902	Bored, 10-inch	125	14	550	46	do	1,120.00	1,250.00	Irrigation	†100
620	S. Buckley	do	N-4	1899	Bored, 12-inch	125	16	100	56	Wind	100.00	150.00	Domestic; stock	
621	James S. Hart	do	N-4		Bored, 7-inch	124		707	54	do			do	
622	do	do	N-4	1883	do	124	120	148	29	Not raised			Not used	
623	T. T. Bradshaw	do	M-4		do	130	12	90	52	Hand			Domestic; stock	
624	E. Yeldon	do	N-4	1902	Bored, 3-inch	130	15	30	158	do			do	
625	L. DeGroote	do	M-3,4	1888	Bored, 7-inch	130	110	100	50	Wind	100.00		Domestic	
626	John Pearson	do	M-4	1895?	do	130	120	87	55	do		300.00	Domestic; stock	
627	E. H. Kincaid	do	M-4	1899	Dug, 3 by 3 foot	130	120	18	51	do			Domestic	
628	Chas. McClain	Sec. 31, T. 2 S., R. 13 W.	M-4		do	135	124	18	103	Not raised			Not used	
629	J. H. McGuire	Sec. 32, T. 2 S., R. 13 W.	M-4	1898	Dug, 2-foot diameter.	135	123	14	60	Hand	15.00		Domestic	
630	Frank Rhodes	Sec. 31, T. 2 S., R. 13 W.	M-4	1895	Dug, 2 by 4 foot	135	124	15	117	Wind			Domestic; stock	
631	O. A. Nelson	Sec. 29, T. 2 S., R. 13 W.	M-3		Hydraulic, 2-inch.	135	122	112	40	do	52.00	130.00	do	
632	do	do	M-3	1904	Bored, 14-inch	135	123	93						
633	Chas. Haddock	Sec. 32, T. 3 S., R. 13 W.	M-3	1891	Bored, 7-inch	135		75	51	Wind			Domestic; stock	
634	do	do	M-3	1899	Bored, 10-inch	135	115	365		Not raised			Not used	
635	M. D. McKee	do	M-4	1903	Bored, 7-inch	130	120	200	47	Hand	213.00	4.00	Domestic; stock	

Wells in Redondo quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
636	M. D. McKee	Sec. 32, T. 3 S., R. 13 W.	M-4		Dug, 3 by 3 foot.	130	120	13	74	Not raised			Not used	
637	Harvey McClain	do	M-4	1889?		130	118	76	40	Hand			Domestic; stock	
638	Lewis Fogle	Sec. 31, T. 2 S., R. 13 W.	M-4	1903	Bored, 6-inch	135	128	29	230+	Wind	$26.00	$50.00	do	
639	do	do	M-4	1890	Dug, 4 by 4 foot.	140	128	14	103	Not raised			Not used	
640	Mrs. N. S. Duncan	do	M-4	1903	Bored, 7-inch	140	122	227	54	Wind	300.00	124.00	Domestic; stock	
641	do	do	M-4	1886	Dug, 4-foot diameter.	140	127	17	85	do			Stock	
642	J. S. Duncan	do	M-4	1903	Bored, 7-inch	140	129	40	79	do	23.00	117.00	Domestic; stock	
643	do	do	M-4	1886	Dug, 4 by 4 foot.	140	130	11	151	Not raised			Not used	
644	H. Leiding	Sec. 32, T. 2 S., R. 13 W.	M-4	1901	Bored, 4-inch	135	118	42	68	Hand	40.00		Domestic; stock	
645	do	do	M-4		Bored, 5-inch	135	113	16	94	Not raised			Not used	
646	Chas. McClain	Sec. 31, T. 2 S., R. 13 W.	M-4	1902	do	135	118	42	76	Wind			Stock	
647	Hurd Bros. Co	Sec. 32, T. 2 S., R. 13 W.	M-3		Bored, 7-inch	135		70	59	do			Domestic	
648	Thomas Quinn	do	M-3	1889	do	135	126	102	55	do	100.00	200.00	Domestic; stock	
649	Fred Korgan	do	M-3	1884					55					
650	T. C. Coakley	do	N-3	1899	Bored, 2-inch			40	59	Hand	80.00		Domestic	
651	Green Meadow school district.	Sec. 29, T. 2 S., R. 13 W.	N-3		do	135			55	Wind			do	
652	Mr. DeBroin	Sec. 32, T. 2 S., R. 13 W.	N-3	1883?	Bored, 7-inch	135			55	Hand			Domestic; stock	
653	do	do	N-3		do	128	119	70	27	Not raised			Not used	
654	F. W. Weeks	do	N-3	1877?	do	128	118	87	55	Wind			Domestic; stock	

655	F. M. Weeks	....do	N-3	1883	....do	128	118	106	....	Compressed air		1,100.00	Irrigation		†60
656	....do	....do	N-3	1880	....do	130	120	114	....	....do			....do		
657	W. Cleland	Sec. 29, T. 2 S., R. 13 W.	N-3	1896	Bored, 2-inch	130	123	97	64	Wind	37.00	95.00	Domestic; stock		
658	D. M. Durrell	Tajanta	N-3	1878?	Bored, 7-inch	130	123	105	61	....do			....do		
659	....do	....do	N-3	1886	....do	130	123	83	27	Not raised			Not used		
660	W. A. Hudson	....do	N-3		....do	130	117	125	52	Wind		100.00	Domestic; stock		
661	....do	....do	N-3	1895	....do	130	118	125	....	Gas	130.00	1,500.00	Irrigation		†60
662	....do	....do	N-3	1903	Bored, 10-inch	130	118	123	....	....do	135.00		....do		†65
663	W. K. Clifford	....do	N-3		Bored, 7-inch	130	119	80	59	Wind	80.00	125.00	Domestic; irrigation; stock.		
664	John Kilroy	Sec. 28, T. 2 S., R. 13 W.	N-3	1902	Bored, 8-inch	130	116	90	64	Hand	100.00	3.00	Domestic; stock		
665	J. N. Stone	Tajanta	N-3		Bored, 7-inch	130	121	105	66	....do			Domestic		
666	Mrs. Moyle	....do	N-4		Bored, 2-inch	124			56	Wind			Domestic; stock		
667	S. W. Newell	....do	N-4	1896	....do	128		78	56	....do	35.00	75.00	....do		
668	....do	....do	N-4		Bored, 6-inch	128		73	....	Not raised			Not used		
669	Mr. Cromwell	....do	N-4		Bored, 7-inch	130		65	56	Hand			....do		
670	W. S. Nay	....do	N-4	1895?	....do	125	119	80	60	Gas			Domestic		
671	....do	....do	N-4		....do	125	122	65	32	Not raised			Not used		
672	Robert Graham	....do	N-4		....do	120	115	180	31	....do			....do		
673	....do	....do	N-4	1903	....do	120	114	74	51	Wind	75.00	50.00	Domestic; stock		
674	A. G. Williams	Sec. 32, T. 2 S., R. 13 W.	N-4		Bored	120			38	Hand			....do		
675	Nicholas Kirst	Sec. 5, T. 3 S., R. 13 W.	N-4	1897	Bored, 9½-inch	120	111	300	42	Wind	550.00	100.00	....do		
676	....do	....do	N-4	1903	Bored, 7-inch	120	111	48	46	Not raised	40.00		Not used		
677	....do	....do	N-4	1903	Dug, 4 by 4 foot	120	111		54	....do			....do		
678	Mr. Atlebury	Sec. 32, T. 2 S., R. 13 W.	M-4		Bored	130			56	Gas			Irrigation		
680	Mr. Wilcox	Sec. 6, T. 3 S., R. 13 W.	M-4		Bored, 4-inch	140	120		37	Wind			Domestic; stock		
682	L. D. Doke	Sec. 5, T. 3 S., R. 13 W.	M-5	1895	Dug	135	110	40	42	Hand		6.00	....do		
683	Joe Burkhardt	Sec. 6, T. 3 S., R. 13 W.	M-5	1890	Bored, 7-inch	150	115	160	41	Wind	170.00		....do		
684	Geo. Meyers	Sec. 7, T. 3 S., R. 13 W.	M-5	1883	....do	165	110	150	40	....do			Stock		

Wells in Redondo quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
685	Geo. Bixby	Sec. 8, T. 3 S., R. 13 W.	M-6	1893	Bored, 3-inch	140			39	Wind			Domestic; stock.	
686	J. R. Haurvorth	Sec. 17, T. 3 S., R. 13 W.	M-6	1903	Dug, 3 by 3 foot.	135	93	46	63	do	$50.00	$56.00	do	
687	Fred Wolfgram	do	M-7	1893	Bored, 7-inch	130	90	207	40	do		*750.00	do	
688	Max Jenney	Sec. 18, T. 3 S., R. 13 W.	L, M-7	1903	Hydraulic, 6-inch.	150	95	235	43	Gas	300.00	500.00	Domestic; irrigation.	
689	William Williams	Sec. 7, T. 3 S., R. 13 W.	M-6	1884	Bored, 7-inch	190	120	159	42	Wind	300.00	90.00	Domestic; irrigation; stock.	
690	Bixby & Hall	do	L-7		do	175	39	157	42	do		75.00	Domestic; stock.	
691	Geo. Bixby	do	L-6		do	180	86		92	Not raised			Not used	
692	do	Sec. 13, T. 3 S., R. 14 W.	L-6	1888	Bored	135	75	250	44	Wind			Domestic; stock.	
693	Jothan Bixby	Sec. 12, T. 3 S., R. 14 W.	L-6	1891	Driven, 3-inch	205		136	44	do			Domestic	
694	Mrs. M. P. Hutchinson	do	L-7	1904	Bored, 4-inch	175	64	168	45	do	210.00	100.00	Domestic; stock.	
695	B. Kirst	do	L-6	1900	Hydraulic, 2-inch.	180	47	168	40	do	45.00		do	
696	C. H. Moser	do	L-6	1888	Bored, 7-inch	160	100	210	40	do		75.00	do	
697	Lawrence Fogle	do	K-6		Hydraulic, 3-inch.	155	15	165	32	do	140.00	110.00	Not used	
698	C. Bohm	do	K-6	1903	Bored, 3-inch	150	23	137	48	do	135.00	75.00	Domestic; stock.	
699	A. Kaeferstein	do	K-6	1891	Bored, 7-inch	170	56	196	44	do	315.00	75.00	do	
700	J. B. Brockley	Sec. 1, T. 3 S., R. 13 W.	L-5	1884	do	185	91	120	44	do	130.00	120.00	do	
701	C. Edgar Smith	Sec. 1, T. 3 S., R. 14 W.	L-4		do	155	147	57	43	do		80.00	do	

702	.....do.....	.....do.....	L-5.....	1895	.....do.....	180	108	150	.....	.....do.....	.....	.....	Not used.....	.....
703	Chas. Haddock.....	Sec. 36, T. 2 S., R. 14 W.	L-4.....	1889?	.....do.....	155	70	175	40	.....do.....	.....	75.00	Domestic; stock..	.....
704	.....do.....	.....do.....	L-4.....	.....	.....do.....	190	93	221	37	.....do.....	.....	.....	Irrigation.....	.....
705	.....do.....	.....do.....	L-4.....	1894	.....do.....	190	100	222	.....	Gas.....	.....	625.00	.....do.....	5
706	Jacob Rhenigans.....	Sec. 1, T. 3 S., R. 14 W.	L-5.....	1885	.....do.....	222	80	146	38	Wind.....	.....	80.00	Stock.....	.....
707	J. G. Howland.....	Sec. 31, T. 2 S., R. 13 W.	L-4.....	1896	.....do.....	145	125	80	45	.....do.....	100.00	.....	Domestic; stock..	.....
708	Mrs. Grace Adams.....	.....do.....	L-4.....	1900	.....do.....	145	125	85	44	.....do.....	.....	35.00	.....do.....	.....
709	Mrs. S. A. Howland..	.....do.....	M-4.....	1895	.....do.....	135	122	150	43	.....do.....	.....	35.00	.....do.....	.....
710	.....do.....	.....do.....	M-10....	1900	Bored, 10-inch..	135	123	255	.....	Gas.....	750.00	3,250.00	Irrigation.....	†85
711	A. J. Howland.....	.....do.....	M-4.....	1900	Bored, 7-inch...	140	.....	.....	43	Wind.....	.....	.....	Domestic; stock..	.....
712	Mr. Oninby.....	.....do.....	L-4.....	1889?	Bored, 6-inch...	140	.....	.....	.....	Not raised.....	.....	.....	Not used.....	.....
713	Demmy Till.....	Sec. 36, T. 2 S., R. 14 W.	L-4.....	.....	Bored, 7-inch...	145	125	110	68	Wind.....	.....	.....	Domestic; stock..	.....
714	W. E. Hughes.....	.....do.....	L-4.....	1896	.....do.....	175	100	275	39	.....do.....	.....	40.00	.....do.....	.....
715	St. Michael School....	Sec. 25, T. 2 S., R. 14 W.	L-3.....	.....	.....do.....	140	.....	.....	39	Hand.....	.....	.....	Domestic.....	.....
716	A. Stoll.....	Sec. 30, T. 2 S., R. 13 W.	L-3.....	.....	.....do.....	135	124	77	83	Wind.....	.....	.....	Stock.....	.....
717	Mrs. M. Gaines.....	.....do.....	M-3.....	1879?	Dug, 3 by 3 foot.	135	125	11	85	Hand.....	.....	.....	Domestic; stock..	.....
719	R. Orsi.....	Sec. 31, T. 2 S., R. 13 W.	M-3.....	1889	Bored, 7-inch...	135	123	360	38	Wind.....	760.00	115.00	.....	.....
720	T. A. McLain.....	Sec. 30, T. 2 S., R. 13 W.	M-3.....	1903	Bored, 5-inch...	130	118	40	100	.....do.....	26.00	130.00	Domestic.....	.....
721	Mr. Egan.....	.....do.....	M-3.....	.....	Bored, 12-inch..	130	119	107	38	.....do.....	.....	.....	.....do.....	.....
722	Andrew Hutflese.....	.....do.....	M-3.....	1901	Bored, 7-inch...	130	118	83	52	Hand.....	91.00	.....	Domestic; stock..	.....
723	Isaac Russell.....	.....do.....	M-3.....	.....	.....do.....	130	119	63	.....	Not raised.....	.....	.....	Not used.....	.....
724	.....do.....	.....do.....	M-3.....	.....	.....do.....	130	118	42	.....	.....do.....	.....	.....	.....do.....	.....
725	Wm. Neill.....	Sec. 29, T. 2 S., R. 13 W.	M-3.....	.....	.....do.....	130	119	91	54	Wind.....	91.00	.....	Domestic; stock..	.....
726	Wm. Price.....	.....do.....	M-2.....	1886	.....do.....	135	121	114	56	Gas.....	150.00	1,100.00	Domestic; irrigation; stock.	.....
727	Richard Montee.....	Sec. 30, T. 2 S., R. 13 W.	M-2.....	.....	.....do.....	130	118	115	54	Wind.....	.....	.....	Domestic.....	.....
729	Pachmayr Bros.....	.....do.....	M-3.....	1900	Bored, 9½-inch..	130	117	87	53	Wind, gas.....	150.00	400.00	Domestic; irrigation; stock.	†40

Wells in Redondo quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
730	H. Girer	Sec. 30, T. 2 S., R. 13 W.	M-3	1899	Dug, 3½ by 3½ foot.	130	119	15	44	Hand			Domestic; stock	
732	Mrs. Fanny Wethern	do	M-3	1903	Bored, 7-inch	130	113	186	42	Wind	*$500.00		do	
733	Eliza Connelly	Sec. 25, T. 2 S., R. 14 W.	L-3		do	140	121	108	45	do			do	
734	do	do	L-3	1904	Bored, 12-inch	140	122		72	Steam			Stock	
735	do	do	L-3		Bored, 7-inch	145	123	277	46	Wind			do	
736	A. Stoll	Sec. 30, T. 2 S., R. 13 W.	L-3		do	140	122	300	71	Gas			Irrigation	
737	do	do	L-3		Bored, 10-inch	140	122	550		do			do	
738	S. R. McCreery	do	L-3	1902	Bored	135	119	290	38	do	850.00		Domestic; stock	
739	L. Schmidt	do	L-2	1896	Bored, 7-inch	135	117	85	52	Wind	85.00	$75.00	do	
740	Geo. Eysenbeich	Sec. 19, T. 2 S., R. 13 W.	M-2	1894	do	135	115	105	60	do	115.00	145.00	do	
741	J. Price	Sec. 29, T. 2 S., R. 13 W.	M-2	1885	do	135	115	96	56	do	96.00	100.00	do	
742	J. F. Davis	do	M-2		do	135	118	120	55	do	140.00		do	
743	W. H. Pierce	Sec. 20, T. 2 S., R. 13 W.	M-2	1899	do	135	118	163	51	do	180.00	300.00	do	
744	August Penkert	Sec. 29, T. 2 S., R. 13 W.	M-3	1893	do	135	122	100	64	do	165.00	150.00	do	
748	W. F. G. Blaikie	Sec. 28, T. 2 S., R. 13 W.	N-2		Bored, 6-inch	145	125	96	56	Wind			do	
749	H. O. Wells	do	N-2	1902	Bored, 7-inch	150		94	62	Hand	94.00	26.00	Domestic	
750	J. Mace	do	N-2	1878	do	150	122	114	65	Wind	130.00	90.00	do	
753	Ray H. Carlton	do	N-3	1897	Bored, 3-inch	140		86	67	Hand	45.00		do	

														tion.	
756	....do	....do	N-3		....do	140			140	Not raised			Not used		
757	Lillie Tubman	Sec. 29, T. 2 S., R. 13 W.	N-3	1903	Bored, 10-inch	135	120	150	68	Gas	200.00	1,000.00	Irrigation	†50	
758	....do	....do	N-3		Bored, 7-inch	135	117	91	57	Wind	91.00		Domestic		
759	F. W. Jackson	....do	N-3	1901	....do	135			66	....do			Domestic; stock		
760	P. Quinn	....do	N-3	1878	....do	135			63	....do			Domestic		
761	E. W. Thaxter	Sec. 28, T. 2 S., R. 13 W.	N-3	1883	....do	130	118	152	67	....do	200.00	94.00	Domestic; stock		
762	Annette Thaxter	....do	N-3	1897	Bored, 10-inch	130	115	150		Steam			Irrigation		
763	John Saul	Sec. 20, T. 2 S., R. 13 W.	M-2	1903	Bored, 7-inch	135	93	97	57	Wind	97.00		....do		
765	S. A. McCrerrey	Sec. 30, T. 2 S., R. 13 W.	L-2	1897	Bored, 9½-inch	135	120	235		Not raised	315.00		Not used		
766	Emil Meyer	Sec. 19, T. 2 S., R. 13 W.	M-2		Bored, 7-inch	135	121	184	50	Wind			Domestic; stock		
767	Burke Bros	....do	M-2		Bored	135			50	Hand			Not used		
768	Mr. Tucker	....do	M-2		....do	140			61	....do			Domestic; stock		
769	J. A. Stephens	....do	M-2	1890	Bored, 7-inch	140	128	180	60	Wind			....do		
770	....do	....do	M-2	1883	....do	140	128	160	230+	Gas			Irrigation	†50	
771	Henry Carner	....do	M-2	1883	....do	140	128	160	61	Wind	175.00	175.00	Domestic; stock		
772	E. P. Merritt	....do	M-2	1903	Bored, 8-inch	142	126	98	57	Gas	100.00		....do		
773	W. I. Smart	....do	M-2	1898	Bored, 7-inch	145	123	84	61	Wind			....do		
774	J. M. Schnitker	....do	M-2	1899	....do	145	130	107		Gas			Irrigation	†45	
775	Henry G. Hill	....do	M-2		....do	145	130	104	63	Wind			Domestic; stock		
776	Peter Wall	....do	M-2		....do	145			56	....do			Domestic; irrigation		
777	Mr. Christman	....do	M-2		....do	145	129	90	59	....do			Domestic; stock		
778	Joe Walker	....do	M-2		....do	145			56	....do			....do		
779	L. E. Brockman	....do	M-2	1903	....do	145	134	94	60	....do	94.00	50.00	....do		
780	Mr. Creary	....do	M-2		....do	145	131	52	69	....do			....do		
781	B. Broderson	Los Angeles City	M-1	1895	....do	154	132	70	72	....do	70.00	275.00	....do		
782	....do	....do	M-1	1903	Bored, 10-inch	154	132	83		....do	117.00	115.00	Irrigation		
783	Jacob Meyer	Sec. 19, T. 2 S., R. 13 W.	L-1	1893	Bored, 7-inch	153	131	135	50	....do		75.00	Domestic		
784	B. W. Tully	....do	L-1	1902	....do	150	130	78	77	....do	78.00		....do		

Wells in Redondo quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
785	Casper Kallenbach	Sec. 19, T. 2 S., R. 13 W.	L-1,2	1899	Bored, 10-inch	145	127	82	.....	Gas	$113.00	$1,658.00	Irrigation	164
786	do	do	L-1,2	1903	Bored, 12-inch	145	127	97	.....	do	220.00	.....	do	
787	do	do	L-2	1885	Bored, 7-inch	145	127	80	68	Wind	80.00	180.00	Domestic	.....
788	J. M. Weiss	do	L-2	1902	do	145	125	80	67	do	80.00	35.00	Domestic; stock	.....
789	V. F. Humbert	do	L-2	1892?	do	145	126	83	70	do	.....	60.00	do	.....
790	Ada Lovell	do	L-2	1900	do	140	.....	84	49	do	90.00	100.00	do	.....
791	C. W. Burrell	do	L-2	.....	do	140	.....	.....	60	do	.....	.....	do	.....
792	Vito Gwidtta	do	L-2	.....	Bored	.....	.....	.....	55	do	.....	.....	Domestic	.....
793	R. W. Brooks	do	L-2	1889	do	140	125	73	57	do	.....	.....	Domestic; stock	.....
794	B. F. Schamp	do	L-2	1902	Bored, 7-inch	140	130	120	47	do	152.00	.....	do	.....
795	J. M. Wheeler	do	L-2	1894	do	140	126	87	62	do	87.00	.....	do	.....
796	James Manning	do	L-2	1874	do	140	132	88	52	do	.....	.....	Domestic	.....
797	do	do	L-2	1874	.....	140	.....	180	.....	.....	.....	.....	.....	.....
798	Mr. Frasier	Sec. 24, T. 2 S., R. 14 W.	L-2	.....	Bored, 12-inch	140	125	66	53	Wind	.....	.....	Domestic; stock	.....
799	G. I. Lyttle	Sec. 19, T. 2 S., R. 13 W.	L-2	1891	Bored, 7-inch	140	67	130	61	do	150.00	100.00	Poultry	.....
800	Mr. Green	Sec. 24, T. 2 S., R. 14 W.	L-2	1896	Bored	145	130	146	47	do	.....	.....	Domestic; stock	.....
801	S. Park	Sec. 19, T. 2 S., R. 13 W.	L-2	1900	Bored, 7-inch	140	.....	70	49	do	.....	.....	do	.....
802	Annie Buser	do	L-2	1902	do	140	125	81	41	do	81.00	35.00	do	.....
803	Mrs. M. Blank	do	L-2	1897	do	140	.....	.....	64	do	.....	.....	do	.....
804	Frank E. Anderson	do	L-2	1902	do	140	125	78	54	Hand	78.00	.....	do	.....

805	Mr. Green	Sec. 24, T. 2 S., R. 14 W.	L-1,2		do	140	126	77	73	Wind			do		
807	do	do	L-1	1902	Bored, 10-inch	145		390		Gas	500.00	1,500.00	Irrigation		
808	R. A. Parmiter	Sec. 19, T. 2 S., R. 13 W.	L-1			145			87	Wind			Domestic; stock		
809	J. Grisenthwaite	do	L-1	1898	Hydraulic, 2-inch.	145	127	87	82	do	30.00	36.00	do		
810	J. Tasker	do	L-1	1895	Bored, 7-inch	145	127	87	80	do			do		
811	Louis Streuber	Sec. 24, T. 2 S., R. 14 W.	L-1		do	140	125		47	do			do		
812	Philip McAnay	do	L-2		do	140	130	63	58	do			Stock		
813	John Wildasin	Sec. 13, T. 2 S., R. 14 W.	L-1	1884	do	140	130	68	72	do	68.00	50.00	Domestic; stock		
814	Carl Reaman	do	L-1	1875	do	143	135	80	74	do			do		
815	H. M. Boggs	do	L-1	1883	do	145	120	70	75	do			do		
816	Qong Ou	do	L-1		do	145			100	Hand			Domestic		
817	John Wildasin	do	L-1	1886	do	145	129	71	63	Not raised			Not used		
818	do	do	L-1	1886	do	145	129	71		Hand			do		
819	Mr. Doster	do	L-1	1891	do	148		50	86	Wind, gas		150.00	Domestic; stock		
820	Geo. Ninner	do	L-1	1891	do	148	131	37	82	Hand	40.00				
821	M. J. Golden	Sec. 18, T. 2 S., R. 13 W.	L-1	1891	do	150	130	50	66	Wind			Domestic		
822	do	do	L-1	1877	do	154	134	315		Not raised			Not used		
823	Mr. Rathwell	do	L-1	1895	do	154			98	Wind			Domestic; stock		
824	L. A. Groff	do	L-1		do	155	126	38	74	do			Domestic		
825	Mr. Rathwell	do	L-1	1901	do	155		254	52	Gas					
826	Mrs. Thompson	do	L-1		do	155			94	Hand			Stock		
827	Chas. L. Peterson	do	M-1	1888	do	155		50?	88	Wind			Domestic; stock		
828	Mr. Horde	Los Angeles city	M-1		do	155			83	do			do		
829	C. Oertly	do	M-1	1902	Bored, 10-inch	155	135	60	100	do	100.00	30.00	do		
830	Rachael Ware	Sec. 18, T. 2 S., R. 13 W.	M-1	1893	Bored, 7-inch	157	125	55	82	Hand			Domestic		
831	H. E. Green	do	M-1	1898	do	157	124	51	59	Wind			Domestic; stock		
832	J. R. Toberman	do	L-1		do	154				do			Not used		
833	A. Stoll	do	M-1	1885	do	155		63	89	do	63.00	150.00	Domestic; stock		
834	Mr. Knowles	do	M-1	1895	do	155	127	100	61	do	100.00		do		
835	E. Mojoneir	do	L-1	1902	do	155	130	67	96	do	67.00		Domestic		

Wells in Redondo quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
836	S. Harris	Los Angeles city.	M-1		Bored, 7-inch	153	126	70	60	Wind			Domestic; stock.	
837	M. J. Harkness	do	M-1		do	155		40	66	do			Domestic	
838	C. A. Mead	do	M-1		do	155	135	65	64	do		$100.00	Domestic; stock.	
839	Mrs. S. A. Boner	Sec. 19, T. 2 S., R. 13 W.	M-1	1895	do	155	129	66	67	do	$66.00		do	
840	N. J. Corette	do	M-1		do	155	121	69	68	do			do	
841	K. B. Norswing	Los Angeles city.	M-1	1887	do	155	130	60	64	Wind, gas		*125.00?	do	
842	H. Wellensiek	do	M-1	1888	Bored	155		60	62	Wind		30.00	do	
843	J. Kroeger	do	M-1	1885	do	156	125	58	68	do			do	
844	Main street public school.	do	M-1		Bored, 7-inch	160	123	55	73	do			Domestic	
846	M. E. Walker	do	M-1	1897	do	160	129	59	75	do	59.00	200.00	Domestic; stock.	
847	Henry Leifer	do	M-1		do	160		40	93	Gas			do	
848	Richard Kidson	do	M-1	1874?	do	165	128	52	84	Wind			do	
849	L. O. Beamer	do	M-1		do	165		80	82	Wind, gas	80.00		Domestic; irrigation; stock.	
850	L. E. Sayre	do	M-1		do	160	124	67		Wind		65.00	Domestic; stock.	
851	John Harlan	do	M-1	1889	do	160		70	94	Wind, gas			do	
852	D. C. Smith	do	M-1		do	170	130	53	75	Wind			do	
853	Mrs. McCartney	do	M-1	1875	do	170		125	54	Hand			do	
854	S. J. Linn	do	M-1	1889	do	170		65	69	Wind			do	
855	Mr. Crum	do	M-1		do	170	128	66	74	do			Domestic; irrigation.	
857	Geo. W. Evans	Sec. 19, T. 2 S., R. 13 W.	M-2	1889	do	158	128	68	41	do			Domestic; stock.	
858	do	do	M-1		Bored, 14-inch	158	136	125		Gas		1,400.00	Irrigation	

859	S. E. Lawrence	do	M-2		Bored, 7-inch	153	138	60	57	Wind		75.00	Domestic; stock		
860	Carl Brockman	Sec. 20, T. 2 S., R. 13 W.	M-2	1886	do	155	126	95	51	do			do		
861	Otto Shermer	do	M-2	1893	do	152		93	57	do	93.00	100.00	do		
862	Mr. Lipps	Sec. 19, T. 2 S., R. 13 W.	M-2	1893	Bored, 6-inch	142	124	74	52	Hand			Domestic		
863	W. M. Vontoble	do	M-2		Bored, 7-inch	146			58	Wind			Domestic; stock		
864	J. H. Bargman	Sec. 20, T. 2 S., R. 13 W.	M-2		do	148	128	93	52	do	93.00	100.00	do		
865	Mrs. Keel	do	M-2	1901	do	150	120	113	58	do	120.00	100.00	do		
866	R. Scuffi	Sec. 19, T. 2 S., R. 13 W.	M-2		do	150	131	62	52	do			do		
867	C. W. Brockman	Sec. 20, T. 2 S., R. 13 W.	M-2	1893	Bored, 4-inch	151	128	70	59	do			Domestic		
868	do	do	M-2	1891	Bored, 12-inch	158	134	113	89	Gas	200.00	1,100.00	Irrigation	†135	
869	do	do	M-1	1891	Bored, 7-inch	161	130	62	57	Wind	62.00	35.00	Domestic; stock		
870	Mrs. Julia Brockman	do	M-1	1904	do	162	130	68	63	do		100.00	do		
871	A. Brockman	do	M-1	1899	do	163	129	72	69	Hand	72.00		do		
872	do	do	M-1	1892	do	165	130	71	86	Wind	71.00	55.00	Domestic		
873	do	do	M-1	1897	Bored, 10-inch	165	130	85		Gas	100.00	1,300.00	Irrigation	†90	
874	do	do	M-1	1897	do	165	130	273		do	450.00		do		
875	J. J. Lovell	Los Angeles city	N-1		Bored, 7-inch	168	128	66	69	Wind			Domestic		
876	D. L. Short	do	N-1	1902	do	170	136	74	59	do	81.00	319.00	do		
877	Los Angeles Rwy. Co	do	M-1	1904	Bored, 10-inch	170	130	200+		Not installed					
878	Mrs. Maggie Sharp	do	N-1	1883	Bored, 7-inch	170	130	61	67	Wind			Domestic		
879	J. P. Thremer	do	N-1	1888	do	170	128	70	61	do			do		
880	South Park	do	N-1	1901	Bored, 10-inch	171	129	172	59	Gas		95.00	Irrigation		
881	A. F. Smith	do	N-1		Bored, 7-inch	170	127	59	58	Wind			Domestic; stock		
882	L. M. Messner	do	N-1		do	170		64		do		75.00	do		
883	A. Snyder	do	N-1		do	170			60	do			Domestic		
884	John Henderson	do	N-1		do	175		90	69	do			Domestic; stock		
885	Henry Sherer	Sec. 20, T. 2 S., R. 13 W.	N-2	1885?	do	149	133	82	46	do		225.00	do		
886	Mr. Thompson	do	N-2		do	151				Gas			Irrigation		
887	J. A. Althouse	do	N-2	1904	do	152			76	Wind			Domestic		
888	J. T. Morgan	do	N-2		do	152	118	90	72	Gas			Domestic; stock		
889	Geo. W. Throop	do	N-2	1903	do	155	123	77	75	Wind	83.00	85.00	do		

Wells in Redondo quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
890	Los Angeles Real Estate Co.	Sec. 20, T. 2 S., R. 13 W	N-2	1896	Bored, 7-inch	155	123	77	.....	Not raised	$80.00	.....	Not used	.....
891	L. H. Belter	....do	N-2	1883	....do	155	122	78	.....	Wind	.....	.....	Domestic	.....
892	Mrs. Killenger	....do	N-2	.....	....do	155	.....	70	68	Gas	.....	.....	Domestic; stock	.....
893	Ascott Park Jockey Club.	....do	N-1	1903	Bored, 14-inch	170	128	270	63	Electric motor	.....	.....	Race track	120
894	W. A. Bly	Los Angeles city	N-1	1901	Bored, 7-inch	177	133	72	59	Wind	.....	$250.00	Domestic	.....
895	Henry Hekri	....do	N-1	1897	....do	177	122	70	67	....do	70.00	145.00	....do	.....
896	Mrs. J. E. Thompson, sr.	....do	N-1	1899?	....do	170	140	74	59	Electric motor	.....	.....	Domestic; irrigation.	.....
897	D. E. Miller	....do	N-1	1900	....do	170	.....	70	55	Wind	.....	.....	Domestic	.....
900	H. N. Petrie	....do	N-1	1900	....do	170	.....	70	43	....do	50.00	150.00	....do	.....
901	Mr. Sutherland	....do	N-1	.....	....do	170	.....	.....	56	....do	.....	.....	....do	.....
902	Peter Black	....do	N-1	1900	....do	170	.....	75	58	....do	.....	.....	Domestic; stock	.....
903	L. F. Brashear	....do	N-1	.....	....do	170	.....	.....	59	....do	.....	.....	Domestic	.....
904	Mrs. Maschaff	....do	N-1	.....	....do	170	.....	.....	61	....do	.....	.....	....do	.....
905	Michael DePiaro	....do	N-1	1898	Bored	170	121	74	65	....do	*225.00	.....	....do	.....
906	California Sewer Pipe Co.	....do	N-1	1895	Bored, 12-inch	170	104	73	67	Steam	.....	.....	Manufacturing	1½
907	F. K. Parker	....do	N-1	.....	Bored, 7-inch	175	.....	.....	65	Wind	.....	.....	Domestic	.....
908	E. B. Price	....do	N-1	1807	....do	174	121	73	58	....do	.....	.....	....do	.....
909	Mr. Thornton	....do	N-1	.....	....do	174	.....	60	55	....do	.....	.....	....do	.....
910	Mrs. Lizzie Preddy	....do	N-1	1900	....do	174	.....	70	61	....do	.....	65.00	....do	.....
911	J. E. Gayman	....do	N-1	1894?	....do	174	126	60	82	....do	.....	.....	....do	.....
912	M. J. Russell	....do	N-1	1899	....do	174	120	66	58	....do	*200.00	.....	....do	.....
913	Anna Mansfield	....do	N-1	1899	....do	170	120	75	89	....do	*200.00	.....	....do	.....

914	Mrs. Carnigie	do	N-1	1901	do	170		65	do				do				
915	Wm. Power	do	N-1	1901	do	170		66			*250.00		do				
916	Mrs. W. H. McKie	do	N 1	1902	do	170	129	75	Wind	65	74.00	67.00	do				
917	Ed. Ross	do	N 1		do	170		64	do				do				
918	W. H. Price	do	N 1	1902	do	172	124	73	do	55	75.00	+130.00	do				
919	E. A. Barrington	do	N 1	1901	do	178		67	do		75.00	36.00	do				
920	Peter Cook	do	N 1	1901	do	178	138	69	do		70.00	36.00	do				
921	I. P. De Wolfe	do	N 1	1901	do	174		57	do		*210.00		do				
922	I. P. De Lee	do	N 1		do	175	125	72	do	60			Stock				
923	do	do	N 1		do	175	112	77	do	60			Domestic				
924	L. M. Appleby	do	N 1	1899	do	175		72	do	66	75.00		Domestic; stock				
925	F. J. Coombs	do	N 1	1897	do	175	119	71									
926	W. F. O'Dea	Los Angeles city	N 1		Bored	175			Wind, gas				Not used				
927	H. V. Stanley	do	N 1		Bored, 7-inch	172		63	Wind				Domestic				
928	Mr. White	do	N 1		do	175		59	do				do				
929	M. I. Wacker	do	N 1		do	175	116	65	do	59			do				
930	Mr. Barnhart	do	N 1		do	175		56	do				do				
931	Ed Kehl	do	N 1	1899	do	175	131	60	do	58			do				
932	C. M. Lincoln	do	N 1	1879?	do	175	125	87	do	70			do				
933	F. F. A. W. H. Dowell	do	N 1	1899	do	175		44	do				Domestic; stock				
934	Mrs. McKinley	do	N 1	1875	do	174	129	80	do				Not used				
935	H. E. Huntington	do	N 1	1900	Bored, 9-inch	176		300	Electric motor				Irrigation				185
936	J. A. Miller	do	N 1		Bored, 7-inch	178	123	63	Wind	55			Domestic				
939	do	do	N 1	1900?	Bored	178		72	do	55			do				
940	A. C. Decker	do	N 1	1903	Bored, 7-inch	176	123	62	do	54	54.15	30.00	do				
941	S. V. Gates	do	N 1	1899	Bored	175		59	do				do				
942	H. K. Bennett	do	N 1	1902	Bored, 7-inch	176	124	72	do	63	56.00	+141.00	do				
943	M. E. Stanley	do	N-1	1900	do	176	124	72	do	55	107.20	−218.00	do				
944	Mrs. Irene Wright	do	N-1	1897?	do	176	129	52	do				Not used				
945	C. H. Christ	do	N-1	1900	do	178		72	do	62			Domestic				
946	I. I. Bliss	do	N-1			178		60	do	60			do				
947	John Sherman	do	N 1	1897	Bored	178	123	66	Electric motor	54		400.00	do				
948	John F. Monroe	do	N-1	1896	Bored, 6-inch	178	121	60	Wind	50			do				
949	W. T. Dunham	do	N 1	1901	Bored, 7-inch	178		60	do	57			do				
950	D. A. Kirkpatrick	do	N 1	1901	do	176	126	64	do	59		20.00	do				

Wells in Redondo quadrangle—Continued.

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951	Mrs. Bennett	Los Angeles city	N 1	1895?	Bored, 7-inch	178	123	62	55	Wind			Domestic; stock	
952	Earnest Eberhardt	do	N 1	1902	do	178	119	76	57	do			Domestic	
953	Mrs. Heuber	do	N 1		do	178	125	58	60	do			do	
954	D. M. Baldwin	do	N-1	1891	do	178	122	64	57	do			do	
955	G. Dumont	do	N 1	1900	do	178	123	70	60	do			do	
956	P. Purcell	do	N 1	1899	do	178			61	do		$300.00	do	
957	A. L. & D. F. Wilson	do	N 1	1887	do	177			55	do	*$350.00		do	
958	W. F. Sherwood	do	N 1		do	178			57	do			do	
959	Mr. Webb	do	N 1		do	178			60	do			do	
960	D. M. Brewer	do	N-1	1903	do	178	132	75	58	do	*300.00		do	
961	Mr. Owens	do	N 1		Bored, 4-inch	178			56	do			Stock	
962	Miss Russell	do	N 1	1903	Bored	178			60	do			Domestic; stock	
963	J. C. M. N. Garner	do	N 1	1902	do	178		70+	55	do	70.00	100.00	Domestic	
964	L. W. James	do	N-1	1901	Bored, 7-inch	178		72	65	Wind, hand	54.25	98.00	do	
967	H. R. Smith	do	N-1	1898	do	178	126	72	60	Wind	80.00	100.00	do	
968	John Engle	do	N-1		do	176		70+	58	do			Domestic; stock	
969	Equitable Trust and Improvement Co.	do	N-1		Bored	176			65	do			Domestic	
970	C. Sanders	do	N-1		do	178			60	do			do	
971	Mr Ingersoll	do	N-1		do	178			60	do			do	
972	M. C. Daugherty	do	N-1		Bored, 7-inch	178			60	do			do	
973	John Cornelson	do	N-1	1899	do	178			59	do			do	
974	Santa Fe R. R.	do	N-1	1894	do	170	128	70	61	do			Stock	
975	W. W. Allved	Sec. 21, T. 2 S., R. 13 W.	N-2	1883	do	160	135	55	79	do			Domestic	

976	Mr. Slauson	do	N-2		Bored, 10-inch	155	125	148		do						
977	I. Madill	do	N-1	1895?	Bored, 7-inch	155			80	do					Domestic; stock	
978	R. J. Lang	do	N-2	1893	do	155	127	88	55	do		100.00	185.00		do	
979	Mr. Slauson	Sec. 20, T. 2 S., R. 13 W.	N-2		do	160			73	do					Irrigation	
980	W. Wieland	Sec. 21, T. 2 S., R. 13 W.	N 2	1884	do	160			89	Gas			150.00		Domestic	
981	Mr. Slauson	Sec. 20, T. 2 S., R. 13 W.	N 2	1900	Bored, 12-inch	160	125	300		do					Irrigation	†235
982	do	do	N 2	1900	do	160	125	270		do					do	
983	W. Niece	Sec. 20, T. 2 S., R. 13 W.	N-3		Bored, 7-inch	134	120	52	60	Wind					Domestic; stock	
984	T. H. Kennan	do	N-3	1898	Bored, 2-inch	137	122	105	68	do		50.00	100.00		do	
985	do	do	N-3	1899	Bored, 9½-inch	135	124	42	167	Not raised		201.00			Not used	
986	Louis Streuber	Sec. 24, T. 2 S., R. 14 W.	L-1	1887	Bored, 7-inch	140	126	440		Gas			810.00		Irrigation	
987	do	do	L-1	1899	Bored, 12-inch	140	122	80	103	do					do	
988	A. Ducuzan	San Pedro	L-9	1904	Bored, 6-inch	30	16	27	93	Hand					Domestic; stock	
989	Sing	do	L 9		do	28		160	66	Wind					Domestic	
990	J. Gless	do	L 9		Bored, 7-inch	36	21		38	Gas					Irrigation	
991	S. Haigh	do	L-9	1898	do	30		220	40	Steam					Domestic; irrigation.	
992	D. H. Thrasher	do	L-9		Bored	30			38	Wind					Domestic	
993	Pete Lalich	do	L-9	1901	Bored, 7-inch	27	7	100+	39	do					do	
994	Thos. Oliver	do	K-9	1898	do	40	15	183	32	Gas		*1,500.00			Domestic; irrigation.	†35
995	N. S. Southmayd	do	L-9	1902	Bored 10-inch	40	21	200	38	do		397.00	500.00		Domestic; stock	
996	J. G. Smith	do	L-9	1896	Dug, 5 by 5 foot	50	28	20		Gas, wind					Domestic; irrigation.	
997	do	do	L-10	1899	Bored, 7-inch	50	28	162	30	do			†80.00		Irrigation	
998	do	do	L-10	1902	Bored, 10-inch	50		200	30	do		286.00			do	
999	F. C. Carrell	do	L-10	1900?	Bored, 6-inch	50		262	34	Wind					Domestic	
1000	O. L. Gridley	do	L-10		Bored, 4-inch	55	25		31	do					do	
1001	F. H. Carrell	do	L-10	1900?	Bored	55	29	400		Not raised					Not used	
1002	McKinley Home	do	L-10		do	55			34	Gas					Domestic	
1003	J. H. Bathrick	do	L-10	1904	Bored, 4-inch	60	30	133	29	Wind		109.00	163.00?		do	
1004	R. E. Ford	do	L-10	1897	do	55	33	288	29	do		210.00	37.00		Domestic; stock	

Wells in Redondo quadrangle—Continued.

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1005	J. W. Barnett	San Pedro	L-10	1903		55	29	350	27	Hand			Domestic; stock	
1006	Geo. Crookshank	do	L 10	1903	Bored, 10-inch	50	25	250	34	Wind	$400.00	$100.00	Domestic; irrigation.	
1007	Mrs. John Francis	do	L-10	1897	Bored, 7-inch				34	do			Domestic; stock	
1008	Fred Pierce	do	L-11		Bored	35			27	do			do	
1009	C. E. Guyre	do	L 12		Bored, 7-inch	55			28	do			do	
1010	J. M. Carson	do	L 12	1903	Bored	55			26	Wind, gas			do	
1011	Geo. T. Stewart	do	L 13	1899	Dug, 3½ by 3½ foot.	78	51	28	230+	Wind			do	
1012	Scrivens Bros	do	L-13	1900	Dug, 3 by 4 foot	70	69	21	75	Hand			do	
1013	A. M. Scriven	do	L-13	1900	Bored, 8-inch	70	50	253	29	Wind, steam	400.00	2,000.00	Domestic; irrigation.	170
1014	do	do	L-13	1900	do	70			85	Wind	27.00	50.00	Domestic	
1015	James Crowley	do	M-13	1896	Driven, 2½-inch.	70	50	36	101	do			Domestic; stock	
1016	J. M. Carson	do	M 13		Bored, 7-inch	48			36	do			do	
1018	A. Vetter	do	K 12		do	90	85	150+	103	do			do	
1020	Wm. Murdock	do	M-13	1894	Dug, 40 feet; bored, 10 feet.	65	20	50	101	do			do	
1021	R. L. Watson	do	N-13	1894	Bored, 2-inch	35	30	40	40	Hand	40.00		do	
1022	do	do	N-13	1897	Dug	40	18	25	121	Wind			do	
1023	Wm. Kupferle	do	N-14	1877	Bored, 12-inch	70	38	60	82	do	125.00	135.00	do	
1024	P. C. Traub	do	N-14	1902	Bored, 7-inch	55		90	26	do			do	
1025	James Brayton	do	N 14	1884	do	55	29	90	64	do			do	
1026	H. F. Lembke	do	N-14		Bored, 12-inch	66		80	167	do			do	

1027	John Hohlbauch	do	N-14	1885	Dug, 45 feet; bored, 7-inch, 115 feet.	65	30	160	53	do			do	
1030	John Kase	do	M-14	1891	Bored, 7-inch	55	30	78	50	do			do	
1031	German Methodist Church.	do	M-14	1899	Bored	55		90	53	do			Domestic	
1032	Mrs. A. O. Springer	do	M-14	1884	Dug, 3½ by 3½ foot.	53	30	25	117	do			Domestic; stock	
1033	H. A. Clark	do	M-14	1898	Bored, 7-inch	54	30	200	73	do			do	
1034	G. A. Neuffer	do	M-14	1888	Dug, 3½ by 3½ foot.	55	25	32	72	do			Domestic	
1035	S. S. Lampson	do	M-14	1899?	Dug, 3 by 3 foot	55	30	28	167	do		125.00	do	
1036	Lincoln school district	do	M-14		Bored	55				do			do	
1037	F. M. Whelchel	do	M-14		Bored, 7-inch	55			33	do			Domestic; stock	
1039	Mrs. L. M. Phillips	do	M-15	1876	Dug, 26 feet; bored, 14 feet.	49	29	40	70	do			do	
1046	Luckerman estate	do	M-15	1884	Dug, 5-foot diameter.	48	25	25	59	do		100.00	do	
1041	Henry Kolkhorst	do	M-16	1901	Bored	30		345	108	do			Domestic	
1042	B. McCoy	do	M-16	1897	Dug, 4 by 4 foot; bored, 11-inch diameter.	30	10	30	88	do	40.00	90.00	Domestic; stock	
1047	Mrs. Scomos	do	N-16			13			34	Hand				
1048	F. Hancock	do	N-16	1880	Bored, 2-inch	13			31	do			Domestic	
1049	Chas. Menveg	do	N-16			9			230+	do			do	
1050	Geo. O'Brien	do	N-16	1881	Dug; bored, 1¼-inch.	9	7	12	38	do			do	
1051	do	do	N-16	1902	Dug, 6-foot diameter, 8 feet; bored, 1¼-inch, 15 feet.	9	7	23	89	Not raised			Not used	
1052	Seaside Water Co	do	N-16	1882	Dug, 20 by 40 foot.	10	7	22	114	Steam			Domestic	
1053	do	do	N-16	1900	Bored, 10-inch	10	7	500		Not raised			Not used	
1054	J. B. Nichols	do	N-16		Bored	8	5	12	43	Hand			Domestic	
1055	John Mattos	do	N-16	1903	Bored, 1½-inch	9	5	20	29	do	15.00		do	
1058	John Joseph	do	N-16	1900	Dug, 6 by 6 foot	26	23	20	79	do			Domestic; stock	
1059	Wilmington Cemetery	do	N-15		Bored	55			29	Wind			Irrigation	
1060	Banning Bros	do	N-15	1892?	Dug, 20-foot diameter.	60	27	42	51	Gas			Domestic; irrigation; stock.	

Wells in Redondo quadrangle—Continued.

Number of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet).	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
1061	Wm. Mauger	San Pedro	N-15	.....	Bored, 14-inch	60	32	42	46	Wind	.....	.....	Domestic; stock	.....
1064	John Gellus	....do	N-15	1894	Bored, 7-inch	40	.....	97	31	....do	*$200.00	.....	Domestic	.....
1065	J. H. Putney	....do	N-15	1888?	....do	40	22	115	32	....do	.....	.....	Domestic; stock	.....
1066	....do	....do	N-15	1902	Dug, 5 by 8 foot.	40	22	21	69	Steam	35.00	.....	Irrigation	.....
1067	Nelson Storey	....do	N-15	1884	Bored, 6-inch	40	24	60	36	Wind	.....	.....	Domestic; stock	.....
1068	Seaside Water Co	....do	N-15	1903	Bored, 12-inch	35	23	783	51	Steam	.....	.....	Domestic	177
1069	....do	....do	N-15	1902	....do	35	.....	380	.....	....do	.....	.....	....do	
1072	Mrs. E. E. Hayes	....do	N-15	1874	Bored, 4-inch	35	.....	.....	29	Wind	.....	.....	....do	.....
1073	....do	....do	N-15	1872	Bored, 7-inch	35	16	33	73	....do	.....	.....	Domestic; stock	.....
1074	Wm. Uldt	....do	N-15	1874	Bored, 12-inch	25	13	24	101	....do	.....	+$300.00	Domestic	.....
1076	Mrs. J. Luede	....do	N-16	1874	.....	20	.....	.....	63	Hand	.....	37.00	....do	.....
1077	John Francis	....do	N-16	.....	Bored, 7-inch	20	10	86	36	Wind	.....	.....	....do	.....
1078	T. M. Matthews	....do	N-16	1901	Dug, 6 by 6 foot.	21	10	19	65	Wind, hand	.....	.....	....do	.....
1079	Alehanda Robbins	....do	N-16	.....	....do	24	10	15	94	....do	.....	.....	Domestic; stock	.....
1080	A. G. Smith	....do	N-16	1903	Dug, 4 by 4 foot.	23	10	18	85	....do	58.00	50.00	Domestic	.....
1081	H. Hilderbrandt	....do	N-16	1878	Dug, 5 by 8 foot.	18	5	17	61	....do	58.00	50.00	....do	.....
1082	Frank Moniz	....do	N-16	1903	Dug, 3-foot diameter.	16	.....	12	88	Hand	.....	.....	....do	.....
1083	Edward Croak	....do	N-16	1903	Dug, 4-foot diameter.	11	5	9	47	....do	15.00	.....	....do	.....
1084	Lorenzo Hegera	....do	N-16	.....	Bored, 2-inch	10	.....	.....	60	....do	.....	.....	....do	.....
1085	Mrs. Mahar	....do	N-16	1867	....do	10	.....	.....	56	....do	.....	.....	....do	.....
1086	H. D. Parsons	....do	M-16	1874	Dug, 6 by 6 foot.	25	4	22	79	Wind	.....	.....	Domestic; stock	.....
1087	T. D. Holladay	....do	M-16	1874	Dug, 4 by 4 foot.	25	5	21	99	....do	.....	.....	....do	.....
1088	J. M. Medena	....do	M-16	1903	Dug, 4 by 5 foot.	26	6	24	55	....do	*250.00	.....	Domestic	.....

1060	Mr. Seaman	do	M-15, 16	1869?	Bored, 7-inch	40	21	100	33	do			Domestic; stock
1080	Bathman & Bradshaw	do	M 16	1871	Bored, 12-inch	21	0	40	37	do			do
1081	I. P. Silva	do	M-16		Bored, 7-inch	21			34	do			Domestic
1082	P. C. Peterson	do	N-16	1903	Dug, 4 by 5 foot	20	2	20	82	do	45.00	185.00	do
1083	H. A. Matthewson	do	M-16	1901?	Bored, 12-inch	20	2	30	47	do			Domestic; stock
1084	Miss S. E. Winslow	do	M-16		Dug, 5-foot diameter.	20	3	20	100	do			Domestic
1085	Manuel Gomez	do	M 16	1880	Bored	20		25+	60	do			do
1086	Wilmington public school.	do	N-16		Bored, 7-inch	25			44	do			do
1087	David Moore	do	M-15	1880	do	60	30	116	36	do			Domestic; stock

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Water-Supply and Irrigation Paper No. 140 Series 0, Underground Waters, 43

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

FIELD MEASUREMENTS

OF

THE RATE OF MOVEMENT OF UNDERGROUND WATERS

BY

CHARLES S. SLICHTER

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
Washington, D. C., August 10, 1904.

SIR: I transmit herewith, for publication, a manuscript entitled "Field Measurements of the Rate of Movement of Underground Waters," prepared by Prof. Charles S. Slichter, professor of mathematics, University of Wisconsin.

The paper presents an amplified exposition of the method of measuring the movement of underground waters which was devised by Professor Slichter in 1901 while working for the hydrographic branch of the United States Geological Survey and which has been already briefly described in Water-Supply Paper No. 67, 1902. Descriptions of the apparatus invented by him for the laboratory study of wells controlling horizontal and vertical movements of underground waters and the results of these studies are also presented. The laboratory studies are also supplemented by detailed accounts of several investigations made in the field.

This paper should be interesting and valuable to engineers and geologists, and the direct application of the results to the study of problems of vital interest to the users of artesian waters should be of great practical value to the general public. A very suggestive and interesting description of the California method of sinking "stovepipe" wells deserves the attention of drillers in unconsolidated deposits throughout our country, while the description of the carefully made tests on typical pumping plants in Texas and New Mexico should appeal to engineers and others who are interested in the problem of raising water for irrigation or other purposes.

Very respectfully,

F. H. NEWELL,
Chief Engineer.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

FIELD MEASUREMENTS OF THE RATE OF MOVEMENT OF UNDERGROUND WATERS.

By CHARLES S. SLICHTER.

INTRODUCTION.

The following paper describes the method and apparatus used in measuring the velocity of underground waters and gives the results of field work done with the apparatus in various parts of the United States, under authority of the hydrographic branch of the United States Geological Survey. The method used in making the measurements was devised by the writer after preliminary tests along the Arkansas River in western Kansas during the summer of 1901. This preliminary work indicated that it was practicable to measure the rate of flow of ground waters by the use of very simple apparatus. Several determinations of the rate of movement of the underflow of the Arkansas were made during that summer. These measurements, it is believed, constituted the first direct determinations of the rate of flow of ground water that had been made in this country. This preliminary work was done in the neighborhood of Dodge, Kans., and at one or two points near Garden, Kans. The photographs reproduced in Pl. I show the locations of the first successful stations, which were established near Garden, Kans. A brief description of the electrical method of measuring the velocities of underground waters resulting from this preliminary investigation was printed in the Engineering News of February 20, 1902, and in paper No. 67 of the Water-Supply and Irrigation series of the United States Geological Survey. Since then, as the result of work carried on in the field and in the laboratory, the apparatus has been gradually improved, and its present form is described in these pages.

The paper will also include some determinations of the manner and rate of flow of water into tubular wells, and descriptions of methods and simple apparatus designed to accurately estimate the capacity of such wells.

CHAPTER I.

THE CAPACITY OF A SAND TO TRANSMIT WATER.

FACTORS INFLUENCING FLOW.

The general laws governing the flow of water through a mass of sand or gravel have been described by the writer in another paper,[a] and will not be repeated in this place. It is sufficient to state that experiments show that the flow of water in a given direction through a column of sand is proportional to the difference in pressure at the ends of the column, and inversely proportional to the length of the column, and is also dependent upon another factor, called the transmission constant of the sand.

TRANSMISSION CONSTANT.

The resistance offered by sand or gravel to the flow of water which is percolating through it is very great. The water is obliged to pass through very small pores, usually capillary in character; indeed, they are much smaller in cross section than the soil particles between which they pass. If the particles of sand or gravel which make up the water-bearing medium are well rounded in form the pores are somewhat triangular in cross section and the diameter of the individual pores is only one-fourth to one-seventh the diameter of the soil particles themselves. Thus if the individual grains of sand average 1 millimeter in diameter the pores through which the water must pass will average only one-fourth to one-seventh of a millimeter in diameter. If to a mass of nearly uniform sand particles larger particles be added the effect on the resistance to the flow of water will be one of two kinds, depending principally upon the ratio which the size of the particles added bears to the average size of grains in the original sand. If the particles added are only slightly larger than the original sand grains, the effect is to increase the capacity of the sand to transmit water, and the more particles of this kind that are added the greater will be the increase in the capacity of the sand to transmit water. If, however, large particles are added, the effect is the reverse. If particles seven to ten times the diameter of the original sand grains be added, each of the new particles tends to block the course of the

[a] The motions of underground waters: Water-Sup. and Irr. Paper No. 67, U. S. Geol. Survey, 1902.

A

B

LOCATION OF FIRST UNDERFLOW STATIONS AUGUST, 1901, NEAR GARDEN, KANS.

A, Station 1, near Point of Rock; *B*, Station 2, south of island.

water. Thus, for example, a large bowlder placed in a mass of fine sand will tend to block the passage of the water. As more and more of the large particles are added to a mass of uniform sand, the rate of flow of water through it will be decreased until the amount of the large particles equals about 30 per cent of the total mass. From this time on the adding of the large particles will increase the capacity of the whole to transmit water until, if a very large quantity of the large particles be added, so that the original mass of fine particles becomes relatively negligible, the capacity to transmit will approach that of the mass of the large particles alone. These facts have an important bearing upon the capacity of gravels to furnish water to wells or to transmit water in the underflow of a river. The presence of large particles is not necessarily to be interpreted as indicating a high transmission capacity of the material, for this is indicated only when the large particles constitute a large fractional per cent of the total mass, as would be the case where the large particles equal 40 or 50 per cent of the whole.

The capacity of any sand or gravel to transmit water can be expressed by means of a single number which is called the transmission constant of the soil. This constant is defined to be the amount of water transmitted in unit time through a cylinder of the soil of unit length and unit cross section under unit difference in head at the ends. For example, if the foot and minute be the units of length and time, and if a column of sand 1 square foot in cross section and 1 foot in length will transmit 1 cubic foot of water a minute under a difference in head of 1 foot of water, the transmission constant is 1. The transmission constant of a soil varies very greatly with the size of the individual grains constituting the sand or gravel, and also depends in a marked degree upon the porosity or amount of open space in the soil. Table I, herewith, gives the transmission constants for a variety of sizes of soil grain and for a series of porosities varying from 30 to 40 per cent. This table is computed for a temperature of the water of 60° F. An auxiliary table, Table II, is one from which the transmission constants corresponding to other temperatures can readily be found.

Transmission constant k is the quantity of water, measured in cubic feet, that is transmitted in one minute through a cylinder of the soil 1 foot in length and 1 square foot in cross section, under difference in head at the ends of 1 foot of water.

The tabulated numbers express the transmission constant in cubic feet per minute.

TABLE I.—*Transmission constants from which the velocity of water in sands of various effective sizes of grain can be obtained.*

Table computed for temperature of 60° F.; results for other temperatures can be found by the use of Table II.]

Diameter of soil grain in mm.	Porosity.						Kind of soil.
	30 per cent.	32 per cent.	34 per cent.	36 per cent.	38 per cent.	40 per cent.	
0.01	0.000033	0.000040	0.000050	0.000060	0.000072	0.000085	
.02	.000131	.000162	.000198	.000239	.000286	.000339	Silt.
.03	.000296	.000364	.0004460	.000538	.000645	.000763	
.04	.000527	.000648	.0007940	.000958	.001145	.001355	
.05	.000822	.001012	.001240	.001495	.001790	.002120	
.06	.001182	.001458	.001784	.002150	.002580	.003050	
.07	.001610	.001983	.002430	.002930	.003540	.004155	Very fine sand.
.08	.002105	.002590	.003175	.003825	.004585	.005425	
.09	.002660	.003280	.004018	.004845	.005800	.006860	
.10	.003282	.004050	.004960	.005980	.007170	.008480	
.12	.004725	.005830	.007130	.008620	.01032	.01220	
.14	.006430	.007940	.009720	.01172	.01404	.01662	
.15	.007390	.009120	.01115	.01345	.01611	.01910	Fine sand.
.16	.008410	.01036	.01268	.01531	.01835	.02170	
.18	.01064	.01311	.01605	.01940	.02320	.02745	
.20	.01315	.01620	.01983	.02390	.02865	.03390	
.25	.02050	.02530	.03100	.03740	.04480	.05300	
.30	.02960	.03640	.04460	.05380	.06450	.07630	
35	.04025	.04960	.06075	.07330	.08790	.01039	Medium sand.
.40	.05270	.06480	.07940	.09575	.1145	.1355	
.45	.06650	.08200	.1005	.1211	.1450	.1718	
50	.08220	.1012	.1240	.1495	.1780	.2120	
.55	.09940	.1225	.1500	.1810	.2165	.2565	
60	.1182	.1458	.1784	.2150	.2580	.3050	
.65	.1390	.1710	.2095	.2530	.3030	.3580	
.70	.1610	.1983	.2430	.2930	.3510	.4155	Coarse sand.
.75	.1850	.2278	.2785	.3365	.4030	.4770	
.80	.2105	.2590	.3175	.3825	.4585	.5425	
.85	.2375	.2925	.3580	.4325	.5175	.6125	
.90	.2660	.3280	.4018	.4845	.5800	.6860	
.95	.2965	.3650	.4470	.5400	.6460	.7650	
1.00	.3282	.4050	.4960	.5980	.7170	.8480	
2.00	1.315	1.620	1.983	2.390	2.865	3.390	
3.00	2.960	3.640	4.460	5.380	6.450	7.630	Fine gravel.
4.00	5.270	6.480	7.940	9.575	11.45	13.55	
5.00	8.220	10.12	12.40	14.95	17.90	21.20	

TABLE II.—*Variation, with the temperature, of the flow of water of various temperatures through a sand, 60° F. being taken as the standard temperature.*

Temperature.	Relative flow.[a]	Temperature.	Relative flow.[a]
° F.	*Per cent.*	° F.	*Per cent.*
32	0.64	70	1.15
35	.67	75	1.23
40	.73	80	1.30
45	.80	85	1.39
50	.86	90	1.47
55	.93	95	1.55
60	1.00	100	1.64
65	1.08		

[a] "Relative flow" means flow at given temperature compared with flow at 60° F. It is expressed as a percentage.

It should be borne well in mind that the rate of transmission varies very greatly with the temperature of the water. For example, a change from 50° to 60° increases the capacity to transmit water under identical conditions by about 16 per cent, while a change from the freezing temperature to a temperature of 75° will nearly double the power of a soil to transmit water. This difference, of course, is not due to any change in the soil itself, but is due solely to the increased ease with which water flows at high temperatures compared to the ease with which it flows at low temperatures. The transmission constant of a sand can also be obtained by use of the diagram given in Pl. II. Graduated vertical lines will be found in this diagram corresponding to the diameter of the soil grains (d), the amount of water transmitted (q), the hydraulic gradient (s), and the porosity of the soil (m). The graduated line marked U is an auxiliary scale. The number d is expressed in millimeters, and q is expressed in cubic feet per minute. The hydraulic gradient s is expressed as a percentage. A slope of the ground water equal to 2 feet in 100 feet appears in the diagram as hydraulic gradient 0.02 and a slope of 528 feet per mile appears as 0.10. The porosity, m, also appears in the diagram as a percentage. The porosity or amount of voids in a sand will usually lie between 25 and 46 per cent of the total volume.

The diagram is used as follows: Suppose that the amount of water transmitted by a sand per square foot of cross section is desired, if the effective size of soil grain is 0.55 millimeter, the hydraulic gradient 2 feet in 100 feet, and the porosity is 36 per cent. Apply a ruler or straight edge (the edge of a piece of letter paper will do) to the diagram, passing through the mark 0.55 on d and the mark 0.02 on s. The edge of the ruler will locate a point 0.47 on U, the exact location

of which should be noted. Then move the ruler so that it will pass through this same point on U and through the mark 36 on m. The place where the ruler crosses the line q (0.0036), will give the discharge in cubic feet per minute. The diagram gives results based upon the assumed temperature of the water of 60° F.[a]

If any three of the four magnitudes d, q, s, m are known, the remaining one can be found in a manner similar to the above.

The removal of larger particles from a mixed sand may not only increase the transmission constant in the manner described above, but such removal may also increase the transmission capacity by permitting the remaining sand to pack in a more open manner, as would be shown by an increased porosity. Tables II and III give results which show that the removal of the larger grains from a sand does not necessarily decrease the transmission constant, but may even increase it. The results given in Table III were obtained by successively removing the larger particles from a mass of sand by means of standard sieves, and then determining the porosity, effective size,[b] and transmission constant for the finer material passing through the successive sieves. The gravel represented by Table III consisted of a mixture of all sizes of grains, from very fine grains to bowlders 2 feet in diameter. All pieces larger than 1 inch in diameter were discarded before the results shown in Table III were obtained. It is interesting to note that the 93.4 per cent of the total sand passing through sieve 2 (2 meshes to the inch) did not have as large an effective size as the 74.2 per cent which passed through sieve 20 (20 meshes to the inch).

Table III is derived from a beach sand. The 54.3 per cent of this sand which passed through sieve 10 has a smaller transmission constant than the 36.8 per cent which passed through sieve 14.

The following table shows the effect of removing, by means of standard sieves, the coarser portions of a natural Arizona gravel. The data in columns 2, 3, 4, 5, and 6 apply to that portion of original sample that passed the sieve named in column 1.

[a] The diagram was computed and drawn for the writer by J. D. Suter, of the University of Wisconsin.

[b] The *effective size* of a sample of sand is such a number that if all grains were of that diameter the sand would have the same transmission capacity that it actually has. It is, therefore, the true mean or average size of sand grain in that sample.

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TABLE III.—*Effect of removing coarser portions of field gravel.*

1. No. of sieve.	2. Quantity of gravel passing.	3. Differences of numbers in column 2.	4. Porosity of portion passing.	5. Effective size.	6. Transmission constant at 80°F.
Meshes to inch.	*Per cent of total weight.*	*Per cent of total weight.*	*Per cent.*	*Mm.*	*Cubic feet per minute.*
2	93.4	6.6	38.1	0.325	0.102
8	No data.	.....	40.0	.320	.120
10	83.7	9.7	38.6	.282	.080
12	82.6	1.1	40.3	.304	.108
14	80.3	2.3	39.5	.282	.086
16	78.0	2.3	39.7	.282	.088
18	76.4	1.6	39.6	.277	.085
20	74.2	2.2	40.6	.317	.119
30	55.9	8.3	41.0	.250	.076
40	32.2	23.7	40.6	.187	.042

The following table shows the effect of removing by means of standard sieves the coarser portions of a natural beach gravel. The data in columns 2, 3, 4, 5, and 6 apply to that portion of original sample that passed sieve named in column 1.

TABLE IV.—*Effect of removing coarser portions of a beach gravel.*

1. No. of sieve.	2. Quantity of gravel passing.	3. Differences of numbers in column 2.	4. Porosity of portion passing.	5. Effective size.	6. Transmission constant at 72°F.
Meshes to inch.	*Per cent of total weight.*	*Per cent of total weight.*	*Per cent.*	*Mm.*	*Cubic feet per minute.*
Total sample.	100.0	.....	37.8	0.810	0.529
10.....	54.3	45.7	40.0	.634	.390
12.....	47.6	6.7	41.7	.640	.457
14.....	36.8	10.8	41.7	.603	.406
16.....	31.4	5.4	42.6	.539	.348
18.....	No data.	.....	43.5	.520	.348
20.....	25.6	5.8	43.5	.494	.314

CHAPTER II.

UNDERFLOW METER USED IN MEASURING VELOCITY AND DIRECTION OF MOVEMENT OF UNDERGROUND WATERS.

TYPES OF APPARATUS.

The apparatus used is of two types: (1) Direct reading, or hand apparatus, requiring the personal presence of the operator every hour for reading of instruments, and (2) recording apparatus, which requires attention but once in a day. Both forms are described in this chapter. The arrangement of the test wells and manner of wiring the wells is essentially the same for both.

TEST WELLS.

The test wells suitable for use with the underflow meter in determining the velocity of ground waters may be common 1½-inch or 2-inch drive wells if the soil is easily penetrated and if the depths to be reached do not exceed 50 to 75 feet. For greater depths and harder soil wells of heavy construction should be used. The 1½-inch drive wells are much preferable to the 1¼-inch wells because of the fact that 1½-inch pipe is lap welded, while the 1¼-inch is butt welded, and less capable of standing severe pounding. The drive point used with the well may be 1½-inch standard brass jacket well points, 42 to 48 inches long, with No. 60 brass gauze strainer. The well points should be threaded with 1½ inches of standard thread, somewhat more than is usually found on the trade goods. The pipe should be full weight strictly wrought-iron standard pipe, cut in lengths of 6 or 7 feet, and threaded 1½ inches at each end. The couplings should be wrought-iron hydraulic recessed couplings, and the thread on the pipe should be cut in such a way that when properly screwed up the ends of the pipe will abut. The recessed couplings protect the pipe at its weakest point, while an ordinary coupling will leave exposed a thread or two of the pipe so that severe driving is liable to swell and ultimately rupture the pipe just above the coupling. Fig. 1 represents a hydraulic coupling, showing a properly made joint.

The driving head should be made of rolled steel shafting and should be about 4 inches long, carrying 1½-inches standard thread and an air hole to permit the free escape of air from the well while the driving

is in progress. A driving ram for putting down the drive wells should be about 5½ feet long by 5½ inches in diameter, made of heavy oak or other tough wood, with iron bands shrunk on the ends, and bearing two handles of hard wood at each end in order to facilitate the handling of the ram by two men. It is convenient to have these handles placed one about 1 foot from one end, and the other about 2 feet from the other end. By reversing the ram the handles are brought in a more convenient position for driving as the well goes down.

Pl. III, *A* illustrates the method of putting down drive points. If the test wells are to be sunk to a depth exceeding that to which drive points can be readily driven, open-end 2-inch pipe should be used. These wells should be made with full weight strictly wrought-iron 2-inch pipe with long threads and recessed hydraulic couplings, as described above. The pipe can either be put down without a screen, in which case a 1¼-inch well point with turned coupling may be inserted through a drive shoe at the bottom of the casing after the pipe is

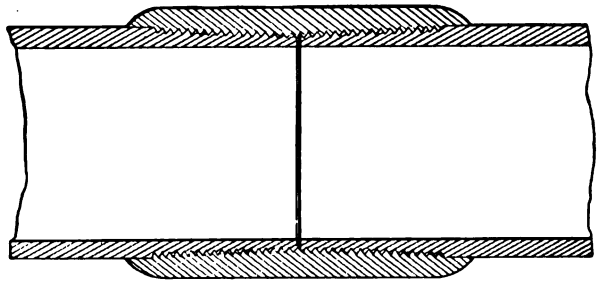


FIG. 1.—Pipe joint made with hydraulic coupling. This joint will stand hard driving.

driven into place, or an open-end brass jacket well point, 48 inches long, may be put down with the pipe. The pipe should be driven into place with a cast-iron ram varying in weight from 150 to 250 pounds, simultaneously hydraulicking a passage for pipe with water jet in three-fourths-inch wash pipe. There are many hand rigs on the market suitable for this work, or a rig can be readily constructed by any good mechanic. Such a rig is shown in Pl. VI, *A*. A suitable pump for the hydraulic jet is a double-acting horizontal force pump with a 4- by 4½-inch cylinder. If the material in which the well is to be drilled is not too hard nor too full of bowlders, the writer recommends that an open-end well point be put down with the casing. This is apt to cause some difficulty in the proper working of the hydraulic jet, by the escape of water through the screen of the well point. This difficulty can be obviated and a more powerful wash secured by admitting a considerable quantity of air along with the water at the suction end of the force pump. The exact amount of air to be admitted can

be readily determined with a little experience. The effect of the air entering the well under high pressure is to form a powerful air lift which will throw the water and gravel out of the top of the well casing with great force. It has been the writer's experience that the best hydraulic samples are obtained with the combination hydraulic pneumatic jet. If the hydraulic jet alone is used the coarser particles have a tendency to remain at the bottom of the well.

After a test is completed the well casing can readily be pulled by a No. 2 cast-iron pipe puller and two 5-ton railroad jacks. Sets of dies for the pipe puller to fit both 1½- and 2-inch pipe can be obtained at small cost. Pl. III, *B*, shows the operation of the pipe puller and railroad jacks.

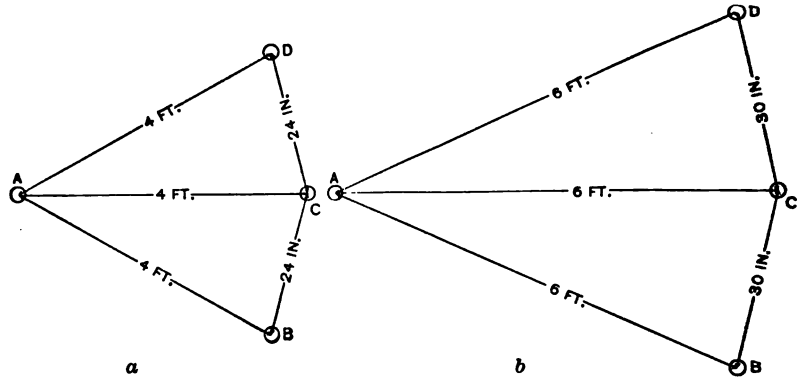
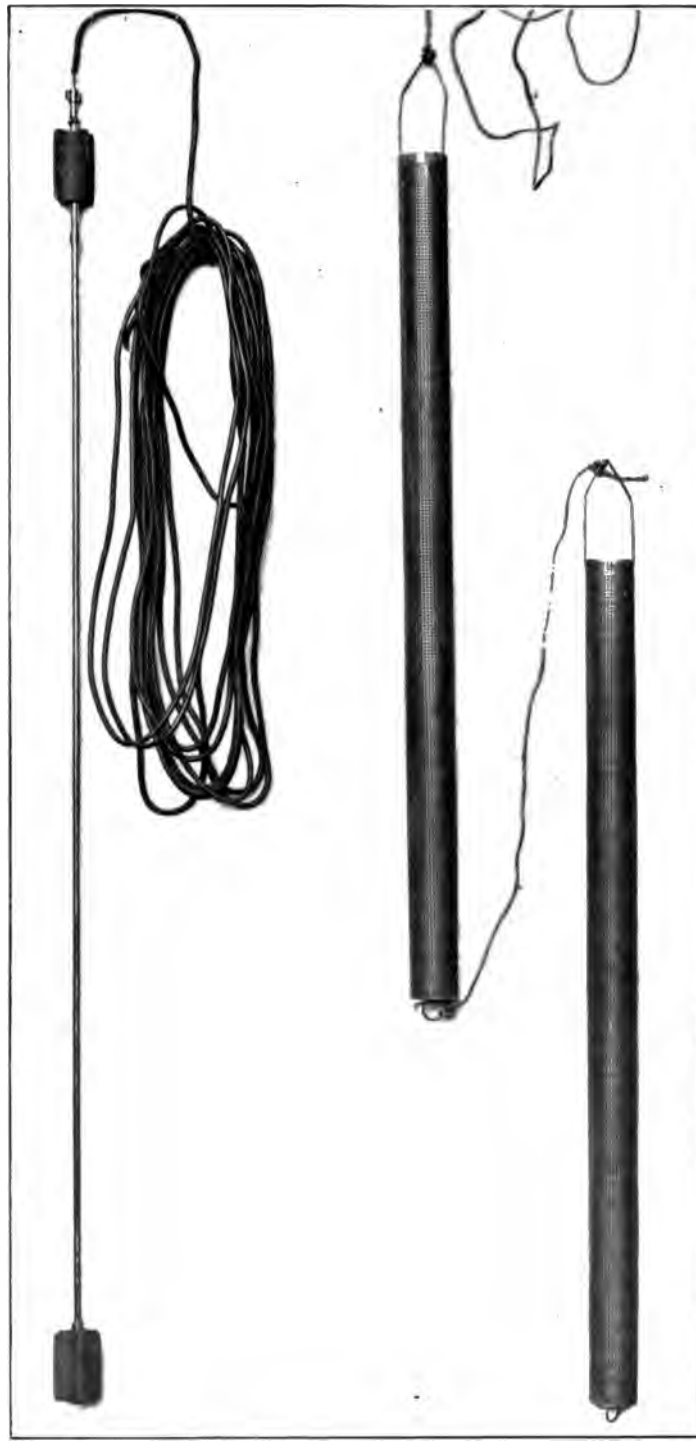


FIG. 2.—Plan of arrangement of test wells used in determining the velocity and direction of motion of ground water: A, B, C, D are the test wells. The direction A–C is the direction of probable motion of the ground water. The dimensions given in plan *a* are suitable for depths up to about 25 or 30 feet, those in plan *b* for depths up to about 75 feet. For greater depths the distances A–B, A–C, A–D should be increased to 9 or 10 feet, and the distances B–C and C–D to 4 feet. The well A is the "salt well" or well into which the electrolyte is placed.

The test wells are driven in groups, as shown in fig. 2, each group of wells constituting a single station for the measurement of the direction and rate of flow of the ground water. In case the wells are not driven deeper than 25 feet, the "upstream" or "salt well" A is located, and three other wells, B, C, and D, are driven at a distance of 4 feet from A, the distance between B and C and C and D being about 2 feet. The well C is located so that the line from A to C will coincide with the probable direction of the expected ground-water movement. This direction should coincide, of course, with the local slope of the water plane, and if this is not accurately known, it should be determined by means of leveling with a level. For deeper work the wells should be located farther apart, as shown in the right portion of fig. 2. For depths exceeding 75 feet, a radius of 8 or 9 feet and chords of 4 feet should be used, the general requirement being that the wells should be as close together as possible, so as to cut down to

A RAM USED FOR DRIVING SMALL WELLS BY HAND.

B. PULLING WELL CASING WITH RAILROAD JACK AND NO. 2 PIPE PULLER.



ELECTRODE AND PERFORATED BRASS BUCKETS USED IN CHARGING WELLS.

a minimum the time required for a single measurement, but not so close that important errors are liable to be introduced by the inability to drive the wells perfectly straight and plumb. On this account the deeper the wells the farther apart they should be placed. The angles B A C and C A D should not exceed 30°.

DIRECT-READING INSTRUMENTS.

Electrical connection is made with the casing of each test well by means of a drilled coupling carrying a binding post. Each of the downstream wells (B, C, D) contains within the well point or screen section an electrode consisting of a nickeled brass rod three-eighths inch in diameter by 4 feet long, insulated from the casing by wooden spools. The end of rod receives a No. 14 rubber-covered wire, to which good contact is made by a chuck clutch. An electrode is shown in Pl. IV. This electrode communicates with the surface by means of a rubber-covered copper wire. Pl. IV also shows two buckets of perforated brass used in charging wells with granulated sal ammoniac; each is 1¾ by 30 inches.

Fig. 3 illustrates the arrangement of electric circuits between the upstream well and one of the downstream wells. Each of the downstream wells is connected to the upstream well in the manner shown in this figure.

A view of the direct-reading underflow meter is shown in Pl. V, *A*. Six standard dry cells are contained in the bottom of the box, their poles being connected to the six switches shown at the rear of the case. By means of these switches any number of the six cells may be thrown into the circuit in series. One side of the circuit terminates in eight press keys, shown at the left end of the box. The other side of the circuit passes through an ammeter, shown in the center of the box, to two three-way switches at right end of the box. Four of the binding posts at the left end of the box are connected, respectively, to the casing of well A, and to the three electrodes of wells B, C, and D, in the order named. The binding posts at the right end of the box are connected to the casings of wells B, C, and D. There are enough binding posts to connect two different groups of wells to the same instrument. When the three-way switch occupies the position shown in the photograph, pressing the first key at left end of the box will cause the ammeter to show the amount of current passing between casing of well A and casing of well B. When the next key is pressed the ammeter will indicate the current between the casing of well B and the electrode contained within it. In one instance the current is conducted between the two well casings by means of the ground water in the soil; in the second case the electric circuit is completed by means of the water within well B. By putting the three-way switch in second position and pressing the first and third

keys in turn, similar readings can be had for current between casings A and C and between casing C and its internal electrode. Similarly with switch in third position, readings are taken by pressing first and fourth keys. The results may be entered in a notebook, as shown in Table V.

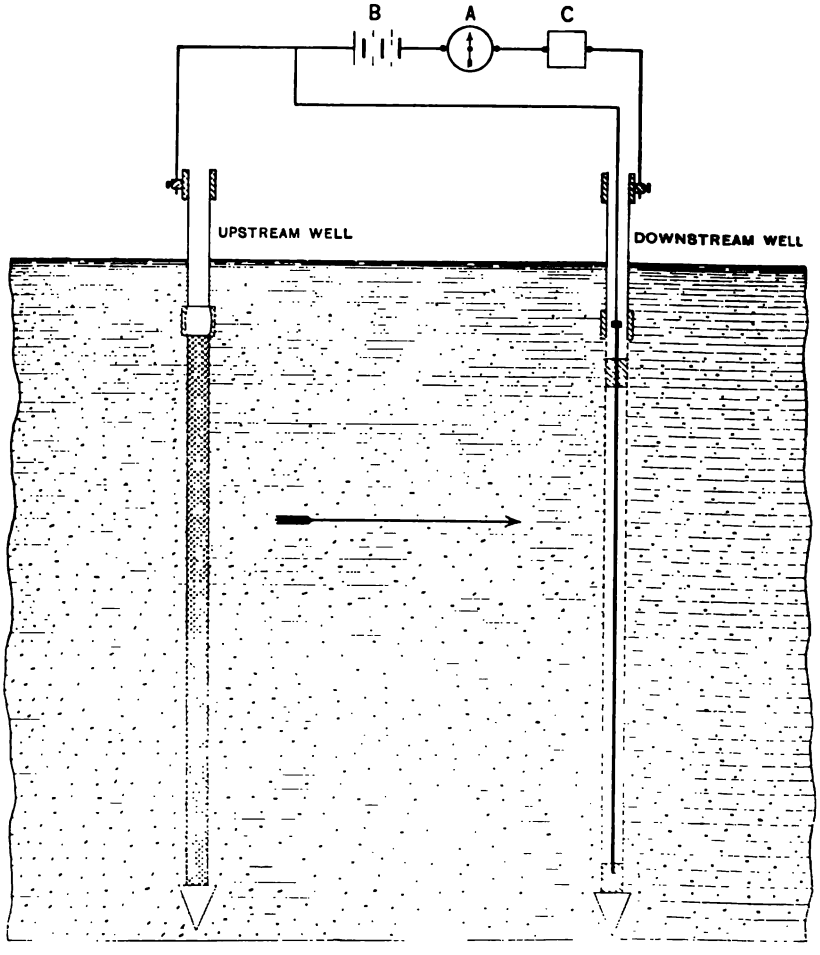


FIG. 3.—Diagram illustrating electrical method of determining the velocity of flow of ground water. The ground water is supposed to be moving in the direction of the arrow. The upstream well is charged with an electrolyte. The gradual motion of the ground water toward the lower well and its final arrival at that well are registered by the ammeter A. B is the battery and C a commutator clock which is used when A is a recording ammeter.

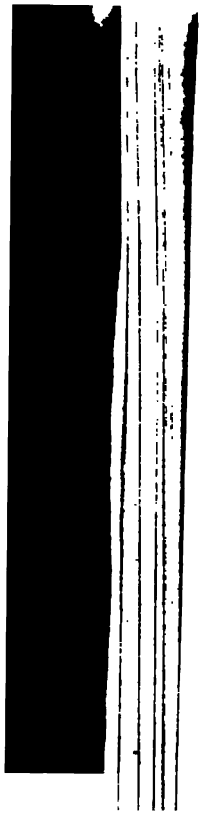
The principles involved in the working of the apparatus are very simple. The upstream well A is charged with a strong electrolyte, such as sal ammoniac, which passes down stream with the moving ground water, rendering the ground water a good electrolytic conductor of electricity. If the ground water moves in the direction of one of the lower wells, B, C, D, etc., the electric current between

A UNDERFLOW METER, SHOWING CONNECTIONS WHEN USED AS DIRECT-READING APPARATUS.

When used with recording ammeter, only two connections are made, one to each side of battery circuit; but the ammeter is left in circuit with the recording instrument to indicate whether the latter is working properly.

B. COMMUTATOR CLOCK, FOR USE WITH RECORDING AMMETER.

The clock makes electrical contact at any five-minute interval.



and B, A and C, or A and D will gradually rise, mounting rapidly hen the electrolyte begins to touch one of the lower wells. When ıe electrolyte finally reaches and enters inside of one of the wells B, :, D, it forms a short circuit between the casing of the well and the ıternal electrode, causing an abrupt rise in the electric current. The esult can be easily understood by consulting Table V and fig. 4, in vhich the current is depicted graphically.

ABLE V.—*Field record of electric current during underflow measurements at station 5, Rio Hondo and San Gabriel River, California, August 5 and 6, 1902.*

[Readings in ampères and decimals of an ampère.]

Time.	Well B.		Well C.		Well D.		Remarks.[a]	
	Casing.	Electrode.	Casing.	Electrode.	Casing.	Electrode.		
8 a. m	0.140	0.360	0.142	0.332	0.150	0.390		
8.15 a. m	Salt.		Salt.		Salt.		1 NaCl	2 NH_4Cl
8.30 a. m	.160		.163		.170			1 NH_4Cl
9 a. m	.168		.170		.180		1 NaCl	
10 a. m	.180	.360	.182	.330	.192	.390		1 NH_4Cl
11.40 a. m	.192	.345	.195	.325	.202	.380		
1 p. m	.202	.340	.202	.320	.210	.370		1 NH_4Cl
2 p. m	.205	.345	.204	.340	.210	.370		
3 p. m	.208	.342	.205	.320	.210	.360	1 NaCl	
4 p. m	.210	.350	.205	.320	.210	.370		
5 p. m	.218	.330	.210	.310	.212	.360		1 NH_4Cl
6 p. m	.225	.330	.210	.310	.218	.360		
7 p. m	.230	.330	.218	.310	.220	.360		
8 p. m	.240	.330	.222	.310	.223	.350	1 NaCl	
9 p. m	.250	.330	.222	.320	.225	.352		
10.30 p. m	.275	.340	.225	.315	.225	.360		
12 p. m	.350	.600	.230	.310	.230	.340		1 NH_4Cl
1 a. m [b]	.420	.850	.240	.310	.230	.340		
2.30 a. m	.510	1.550	.240	.310	.230	.340		
4.15 a. m	.560	2.000	.240	.310	.230	.340		
5.30 a. m	.550	2.200	.230	.310	.230	.330		
7.45 a. m	.520	2.250	.230	.310	.225	.330		
8.15 a. m		2.250						
9 a. m		2.200						

[a] The electrolyte was lowered into well A by means of a perforated brass bucket, 11 by 30 inches in size. The formula "2 NH_4Cl" means that two of these buckets, full of ammonium chloride, were introduced into well A at the time indicated. Each of these buckets held 2 pounds of the salt.
[b] August 6.

The time that elapses from the charging of the well A to the arrival of the electrolyte at the lower well gives the time necessary for the ground water to cover the distance between these two wells. Hence

if the distance between the wells be divided by this lapse of time, the result will be the velocity of the ground water. The electrolyte does not appear at one of the downstream wells with very great abruptness; its appearance there is somewhat gradual, as shown in the curves in

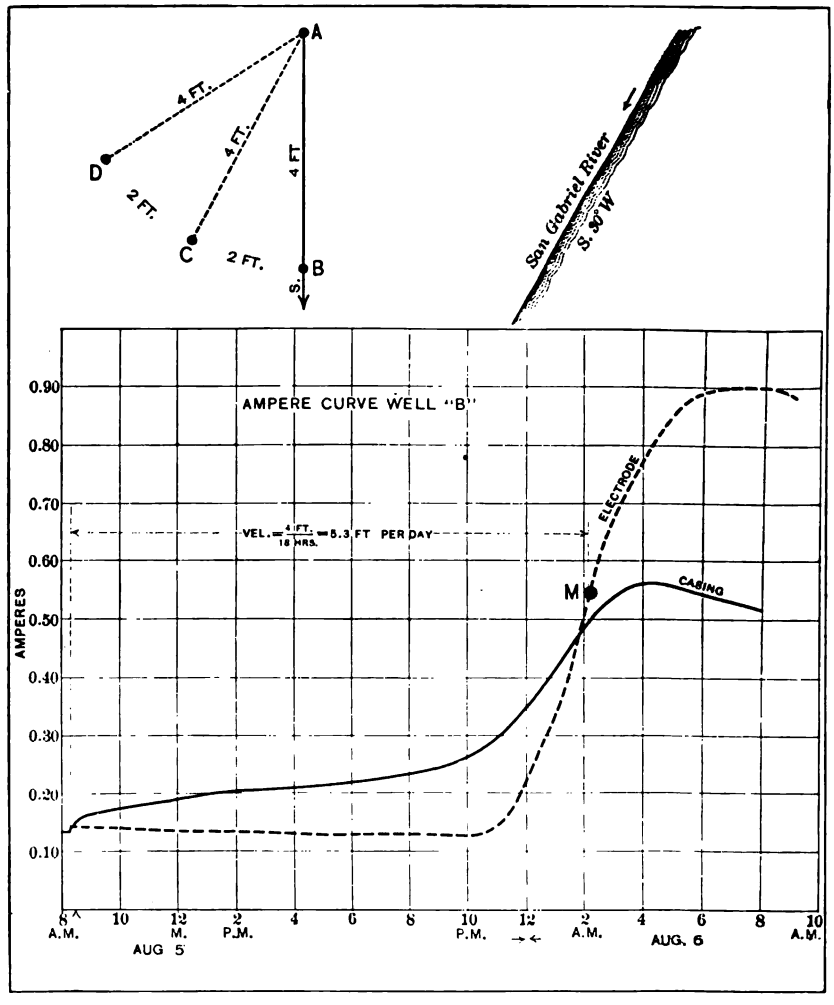


FIG. 4.—Diagram showing ampère curves at station 5 in the narrows of the San Gabriel River, California. The heavy curve represents the strength of electric current between the casing of well A and casing of well B. The dotted curve represents the strength of current between the electrode in well B and the casing of well B. These curves illustrate results obtained with the direct-reading form of apparatus.

figs. 4 and 5. The time required for the electrolyte to reach its maximum strength in one of the downstream wells (and hence, for the current to reach its maximum value) may vary from a few minutes in a case of high ground-water velocity to several hours in a case of low velocity. The writer formerly supposed that the gradual appearance

of the electrolyte at the downstream well was largely due to the diffusion of the dissolved salt, but it is now evident that diffusion plays but a small part in the result. The principal cause of the phenomena is now known to be due to the fact that the central thread of water in each capillary pore of the soil moves faster than the water at the walls of the capillary pore, just as the water near the central line of a river channel usually flows faster than the water near the banks. For this reason, if the water of a river suddenly be made muddy at a certain upstream point the muddy character of the water at a downstream point will appear somewhat gradually, being first brought down by the rapidly moving water in the center of the channel, and later by the more slowly moving water near the banks. The effect of the analogous gradual rise in the electrolyte in the downstream well requires us to select the "point of inflection" of the curve of electric current as the proper point to determine the true time at which the arrival of the electrolyte should be counted. This point is designated by the letter M in figs. 4 and 5.

Owing to the repeated branching and subdivision of the capillary pores around the grains of the sand or gravel, the stream of electrolyte issuing from the well will gradually broaden as it passes downstream. The actual width of this charged water varies somewhat with the velocity of the ground water, but in no case is the rate of the divergence very great. The manner in which the electrolyte spreads has been carefully investigated and will be described in a later page.

It is possible to dispense with the circuit between the casing of well A and the casing of each of the other wells, as the short circuit between the well and electrode forms the best possible indication of the arrival of the electrolyte at the downstream well. For cases in which the velocity of ground water is high, the circuit to well A is practically of no value; but for slow motions this circuit shows a rising current before the arrival of the electrolyte at the lower well, often giving indications of much value to the observer.

The method can be used successfully even though nothing but common pipe be used for the wells. In this case, however, the absence of screen or perforations in the wells renders the internal electrodes useless, and one must depend upon the circuit from well casing of the upstream well to well casing of downstream well.

The results shown in fig. 5 present such a case. In this case the wells were not provided with well points, but merely possessed a 4-foot length of pipe, provided with four or five holes on opposite sides of the pipe containing small ½-inch washer screens. These few openings are not sufficient to permit the electrolyte to enter the well freely, so that readings between casings were relied upon for results. As a matter of fact, enough of the electrolyte did get into the well to give small increased readings, but in order to obtain the electrode readings

shown in the diagram water was removed from the downstream wells by a small bucket holding about 6 ounces, so as to force a quantity of the water surrounding the well into the perforated sections. In cases where good well points are used the ground water charged with the electrolyte finds its way gradually and naturally into the well. The well point should be clear enough to allow as free passage into the well as through the soil itself. This is easily accomplished by pumping water from each test well with a common pitcher pump for a few minutes or until the water is fairly clear.

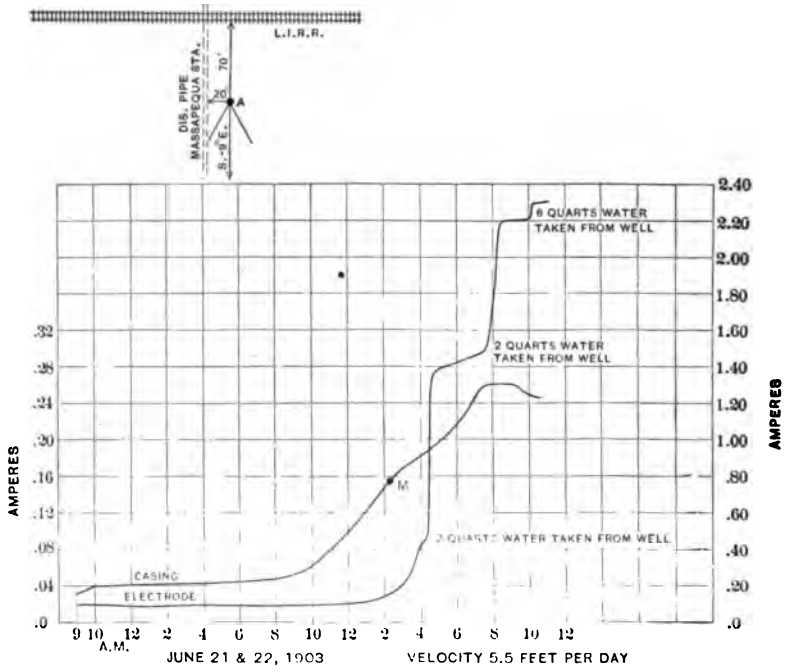


FIG. 5.—Ampere curves at station 1, Long Island, N. Y., showing possibility of use of direct-reading apparatus when well points are not used. The casing in this instance consisted of common black 2-inch pipe, with a few small holes in bottom section. The "casing" curve must be relied upon for determining velocity. The "electrode" curve was obtained by drawing water from well C, as shown on diagram, the charged water being drawn into the well through the small holes and the open end of well.

Granulated sal ammoniac is used to dose well A. A single charge may vary from 4 to 10 pounds. If common pipe without points or screen is used for the wells, so that internal electrodes must be dispensed with, doses of about 2 pounds each should be repeated about every hour. The dry salt should not be poured directly into the well, but should be lowered in perforated buckets, a photograph of one being shown in Pl. IV. These buckets are $1\frac{3}{4}$ by 30 inches and hold about 2 pounds of the salt. Two of these buckets may be tied one above the other for the initial charge, and followed by two more in ten or twenty minutes.

If the wells are not too deep, the sal ammoniac may be introduced into the well in the form of a solution. A common bucket full of saturated solution is sufficient. There is an uncertainty in introducing the sal ammoniac in solution in deep wells, as the time required for the solution to sink to the bottom of the well may be considerable.

The direct-reading ammeter used in the work has two scales, one reading from 0 to 1.5 amperes and the other from 0 to 5 amperes. With a given number of cells, the amount of current between the upstream and a downstream well will depend, of course, upon several factors, such as the depth and distance apart of the wells, but more especially upon the amount of dissolved mineral matter in the ground water. The initial strength of the current can be readily adjusted, however, after the wells have been connected with the instruments, by turning on or off some of the battery cells by means of the switches at the rear of the box. It is a good plan to use enough cells to give an initial current between one-tenth and two-tenths of an ampere.

RECORDING INSTRUMENTS.

In the second form of underflow meter a self-recording instrument is used in place of the direct-reading ammeter, thus doing away with the tedious work of taking the frequent observations day and night, which are required when direct-reading instruments are used. The arrangement of the apparatus is not materially different from that described above. In the place of the direct-reading ammeter a special recording ammeter is used, of range 0 to 2 amperes. It has been found practicable, although it is a matter of some difficulty, to construct an instrument of this low range that is sufficiently portable for field use and not too delicate for the purpose for which it is intended. The ammeter has a resistance of about 1.6 ohms and is provided with oil dash pot to dampen swing of arm carrying the recording pen. The instruments were manufactured by the Bristol Company. They have gone through hard usage in the field without serious breakage or mishap. The portability of the instruments will be materially increased by changes in design which are now being made.

The method of wiring the wells when the recording instruments are used is slightly changed. In this case one side of the battery circuit is connected to casing of well A and to all of the electrodes of wells B, C, and D. The other side of the battery is run through the recording ammeter to a commutator clock, which once every hour makes a contact and completes the circuit, one after the other, to a series of binding posts. One of these binding posts is connected to the casing of well B, one to the casing of well C, and one to the casing of well D. The period of contact is ten seconds, which gives an abundance of time for the pen to reach its proper position and to properly ink its record.

Pl. V, *B* shows a commutator clock made for this purpose by instrument maker of the College of Engineering, University of Wisconsin. The clock movement is a standard movement of fair grade, costing less than $5. It can readily be taken from the case for cleaning or oiling and quickly replaced. A good movement with powerful springs is best for this purpose.

It will be seen from the method of wiring the wells that the record will show the sum of the current between well A and well B added to the current between the casing of well B and its electrode. The removal of the connection to well A would permit the record to show the current between the casing of a downstream well and its electrode, but the connection to the upstream well involves no additional trou'.e and occasionally its indications are of much service, especially if the velocities are low.

One of the instruments above mentioned can be placed in a common box, 16 by 22 by 36 inches, covered with tar paper and locked up. Pl. VI, *B*, is a view of the instruments thus arranged. The shelf contains the recording ammeter (shown at left of cut) and the commutator clock (shown at right of cut).

The contacts on the commutator clock are arranged about five minutes apart, so that the record made for the wells will appear on the chart as a group of lines, one for each downstream well, of length corresponding to the strength of the current. The increasing current corresponding to one of the wells will finally be indicated by the lengthening of the record lines for that well. This can be seen by consulting the records shown in Pl. VII. The record charts are printed in light-green ink and red ink is used in the recording pen, so that record lines can be distinguished when superimposed upon the lines of the chart. A special chart has been designed for this work and is furnished by the Bristol Company as chart 458.

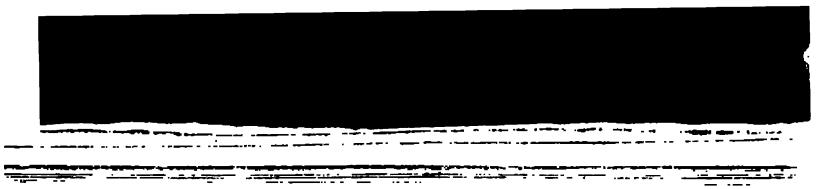
Pl. VII shows two charts made by recording ammeter. In the upper the electrical current for wells B, C, and D, at station 14, Long Island, is recorded, in the order named, at 2.10, 2.15, and 2.20 p. m., and hourly thereafter, the current remaining nearly constant at .22 to .24 ampère until 10.15 p. m., when the current for well C rises as indicated in the chart. In the lower chart the electrical current for wells B, C, and D is recorded, in the order named, at 6.30, 6.35, and 6.40 p. m., and hourly thereafter. The current for wells B and D remains constant at .25 ampere, but the current for well C rises as shown.

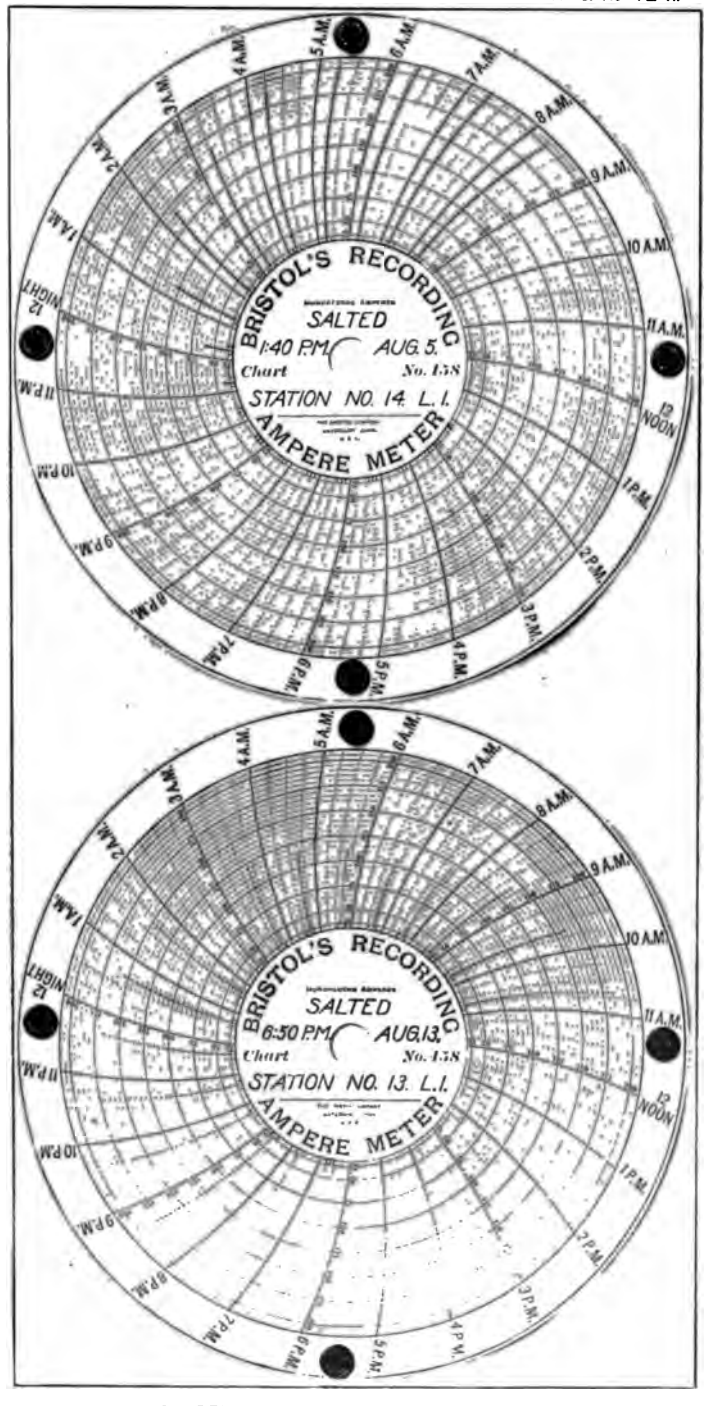
The recording instruments in use have given perfect satisfaction and the method is a great improvement in accuracy and convenience over the direct-reading method. The highest as well as the lowest ground-water velocities yet found have been successfully measured

A. SIMPLE FORM OF SMALL WELL-JETTING RIG.

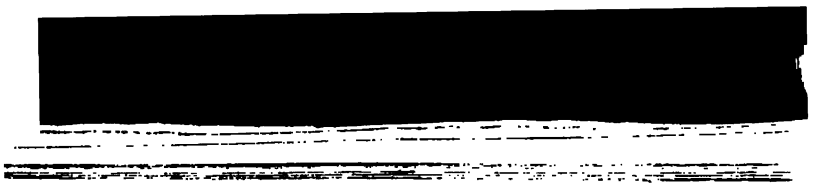
The men driving with 150-pound weight stand on platform attached to drivepipe.

B. RECORDING AMMETER, COMMUTATOR CLOCK, AND BATTERY BOX IN USE IN THE FIELD ARRANGED IN A ROUGH BOX, 16 BY 22 BY 36 INCHES IN SIZE.





CHARTS MADE BY RECORDING AMMETER.



by the recording instruments. By using one or two additional dry cells the instrument may be made quite as sensitive as the direct-reading type. In using the recording instruments but a single dose of salt need be placed in the upstream well. If the wells are deep, it is important to use enough salt solution to make sure that the salt reaches as deep as the screen of the well point immediately after the solution is poured into the well. A gallon of solution will fill about 6 feet of full-weight wrought-iron pipe, so that 10 gallons of solution should be used if well is 60 feet deep. If the proper amount of solution be not used, it will take an appreciable time for the solution to reach the bottom of the well by convection currents, and the results

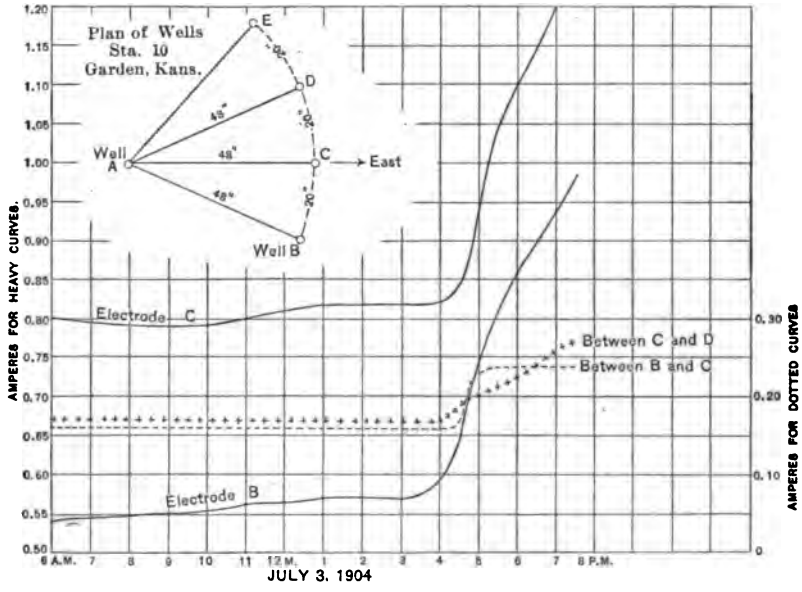


FIG. 6.—Ampere curves at station 10, Garden, Kans. The heavy curves represent the electric current between the casings of wells B and C and the electrodes inside of them. The dotted curves represent the electric current between wells B and C and between C and D. The electric current for the electrode of well B rose earlier than for well C, and the electric current between wells B and C rose earlier and more abruptly than for wells C and D, indicating that the principal stream of electrolyte passed between wells B and C and nearer to well B than to well C.

will be vitiated to that extent. As before stated, it is preferable to introduce into the well granulated sal ammoniac contained in a suitable bucket in case the depth of the well renders the use of a solution uncertain.

In order to properly interpret results obtained in the field with the apparatus, it becomes necessary to investigate the behavior of the dissolved electrolyte as it moves onward with the ground water after leaving the salted well. This matter could be investigated only in the laboratory, and it was sought to reproduce as nearly as possible the conditions found in the field.

Before salting the upstream well of any set of test wells the electric circuit should be closed between each adjacent pair of downstream wells, and the current should be measured with the direct-reading ammeter and recorded in the notebook. An occasional reading of these same circuits will prevent the electrolyte from passing between two of the downstream wells without the knowledge of the observer. This is clearly shown by the results obtained with the set of wells represented in fig. 6. At the location of this station the direction of the flow was at first not correctly estimated on account of its nearness to a river whose height was fluctuating. For that reason the downstream wells were redriven at distances of but 20 inches from one another. The diagram gives the ampère curves for wells B and C, both of which were reached by the electrolyte, and also the curves of current between wells B and C and wells C and D. The actual direction of flow can be seen from these curves to lie between B and C, and probably nearer B than C, since the curve for B rises somewhat earlier and the percentage increase in current is greater. The same fact is shown by the curves representing the current between B and C and between C and D. The main stream of electrolyte must have passed between B and C, as is shown by the more abrupt and earlier use in the current between B and C as compared to that between C and D.

CHAPTER III.

LABORATORY EXPERIMENTS ON THE FLOW OF WATER THROUGH SANDS AND GRAVELS.

OBJECTS OF THE EXPERIMENTS.

During the winters of 1902–3 and 1903–4 experiments were carried on in the laboratory upon the flow of water through sands and gravels contained in tanks. The objects of these experiments were: (1) To verify the law of flow of water through sands and gravels under gradients similar to those found in the field; (2) to ascertain the law of distribution in a horizontal plane of the electrolyte used in the electrical method of determining the rate of flow of underground water; (3) to determine the influence of varying velocities upon this distribution; (4) to determine, if possible, by means of apparatus approximating actual field conditions, the relation between the distribution of the electrolyte and the current curve obtained by the electrical method of measuring ground-water velocities, thereby checking the accuracy of the method and furnishing data indicating more definitely the point on the current curve which should be selected in order to find the velocity of flow.

For the laboratory work of 1902–3 the writer had the assistance of Mr. Henry C. Wolff, and the work of 1903–4 was done by Mr. Ray Owen and H. L. McDonald.

EXPERIMENTS IN THE HORIZONTAL TANK.

The apparatus used in the first experiments consisted of a horizontal wooden tank of inside dimensions 4 feet 6 inches long, 4 feet wide, and 8 inches deep. A chamber of perforated sheet brass 3 inches wide was inserted in each end of the tank, so that the dimensions of the compartment left for the gravel was 4 by 4 feet in horizontal extent. The area 4 by 4 feet was divided into squares 6 inches on a side, at the corner of each of which a small well of slotted sheet brass, one-half inch in diameter, was fixed in position. A larger well, 2 inches in diameter, of the same material was placed in position as shown in the plan, fig. 7. For the first experiments the tank was filled with about 7 inches of gravel, which we have designated as Picnic Point gravel. The effective size of this gravel, as determined by King's aspirators, was 0.93 mm. Mechanical analysis of the Picnic Point gravels will be found in Table VI.

TABLE VI.—*Mechanical analysis by standard sieves of several gravels referred to in the text.*

No. of screen-meshes to inch.	Size of separation of screen in millimeters.	Percent of total weight of sand passing sieve.		
		Picnic Point gravel.	Madison glacial gravel.	Victorville gravel.
100	0.18	00.6	00.8	00.1
80	.23	1.0	1.4	0.2
60	.32	1.6	6.3	1.3
40	.46	4.2	38.6	4.7
30	.70	14.3	83.9	13.1
20	.93	25.6	98.1	27.8
16	1.30	31.4	99.6	37.2
14	1.40	36.8	100	46.3
12	1.70	47.6	100	63.9
10	2.04	54.3	100	71.0
8	2.48	67.5	100	82.7
Held by 8	.....	32.5	.....	17.3

TABLE VII.—*Effect of formalin in preventing clogging of sand filter.*

1	2	3	4	5	6	7
Duration of experiment.	Average head.	Average flow of water per one-fourth hour.	Flow per unit head.	Temperature.	Mean hydraulic gradient per mile.	Velocity of water per diem.
	Inches.	*Pounds.*		°C.	*Feet.*	*Feet.*
First experiment, Dec. 8:						
First 10 4 hours	0.230	6.57	28.56	14.4	25.3	15.4
Second 11 4 hours	.227	6.48	28.54	.....	.....	.....
Second experiment, Dec. 9:						
First 11 4 hours	.188	6.13	30.96	14.0	20.5	14.2
Second 11 4 hours	.185	6.01	30.90	.....	.....	.....
Third experiment, Dec. 11:						
First 5 4 hours	.170	5.75	29.22	14.0	18.9	13.7
Second 5 4 hours	.174	5.89	29.24	.....	.....	.....

NOTE.—This table shows the influence of a small amount of formalin in preventing the clogging of a sand filter when water is run through it continuously. Compare the flow per unit head during first portion of each experiment with the flow during the second period, as given in column 4. The experimental error is greater than the small differences in these numbers. The low gradients and the low velocities used can be seen in columns 6 and 7.

The tank of gravel was securely mounted in a horizontal position and gages of glass tubing communicating with the chambers at the

ends of the tank were adjusted to show the level of water at each end of the tank. By means of these gages it was easily possible to measure the height of the water in the end compartments within one two-hundredths of an inch. Water was permitted to flow into one of the end compartments from galvanized tubs placed on a platform scale. From the tubs the water passed through 3 or 4 feet of rubber tubing

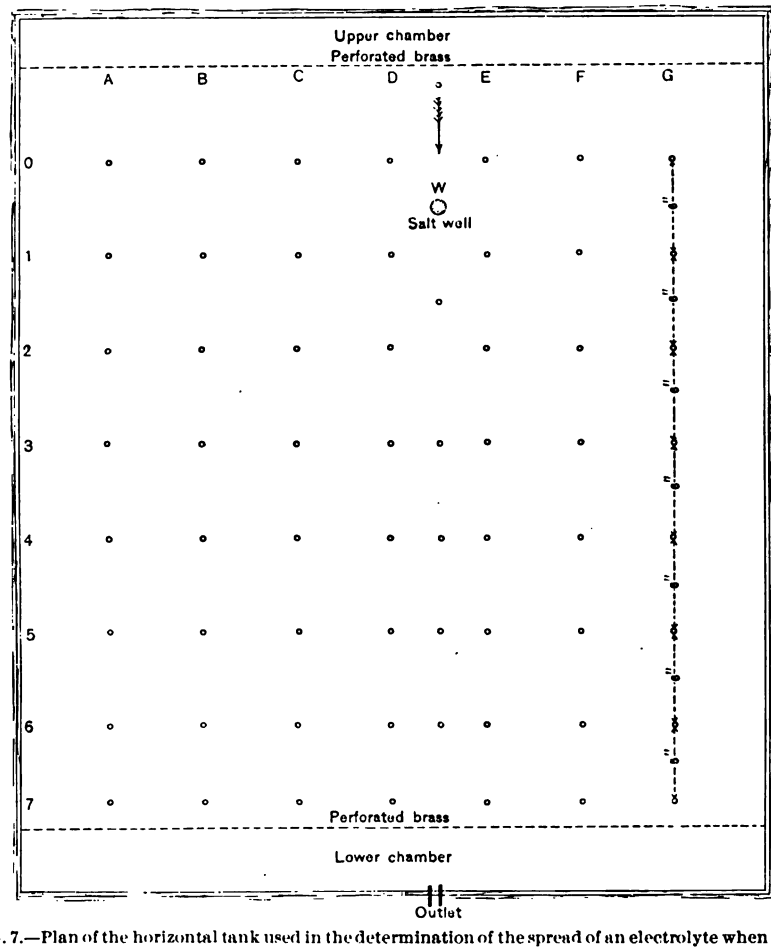


FIG. 7.—Plan of the horizontal tank used in the determination of the spread of an electrolyte when flowing with the water through a sand or gravel. The tank was 4 feet 6 inches long, 4 feet wide, and 8 inches deep. Two perforated brass screens 3 inches from each end left a compartment for gravel 4 by 4 feet in area. A 2-inch well of perforated brass was set at the point marked W, in which the electrolyte was placed. The small circles represent the location of the test wells, from which samples of water could be taken as desired.

to a conically ground needle valve operated by a float placed in the upper compartment or chamber of the tank. It was found possible so to adjust this valve that the level of the water in the upper compartment was maintained constant during an experiment extending over several hours. The water was permitted to escape from the lower

compartment in the tank by means of a ½-inch pipe, the height of the overflow being adjustable.

TABLE VIII.—*Data obtained during experiments on flow of water in horizontal tank.*

No.	Date of experiment, 1902-3.	Hydraulic gradient.	Average depth of water.	Velocity of ground water.	Velocity per unit head.	Temperature of water.	Salt used in experiment.
		Ft. per mile.	*Inches.*	*Ft. in 24 hrs.*	*Ft. in 24 hrs.*	°C.	
1....	Dec. 8	25.30	5.84	15.4	0.61	14.4	None used.
2....	Dec. 9	20.50	5.83	14.2	.69	14.0	Do.
3....	Dec. 11	18.90	5.82	13.7	.63	14.0	Do.
4....	Dec. 20	18.70	5.88	13.2	.70	20.5	Dry NH_4Cl.
5....	Jan. 3	17.60	5.12	12.9	.73	20.0	Do.
6....	Jan. 7	21.45	5.10	12.1	.56	18.8	Dry NaCl.
7....	Jan. 14	22.00	5.12	13.8	.63	17.8	Con. NH_4OH.
8....	Jan. 17	18.54	5.09	9.3	.50	18.8	Do.
9....	Jan. 30	18.92	5.18	11.6	.61	17.8	Dry $\frac{9}{10}$ H_4Cl. $\frac{1}{10}$ NaOH.
10....	Feb. 9	19.03	5.17	11.25	.59	20.0	Dry $\frac{9}{10}$ NH_4Cl. $\frac{1}{10}$ NaOH.
11....	Feb. 18	21.45	5.15	11.68	.54	18.8	Sol. NH_4Cl.
12....	Feb. 23	42.35	5.28	21.70	.51	19.1	Do.
13....	Mar. 3	64.90	5.21	36.00	.55	20.1	Do.
14....	Mar. 9	64.24	5.21	35.5	.55	20.3	Sol. $\frac{9}{10}$ NH_4Cl. $\frac{1}{10}$ NaOH.
15....	Mar. 16	66.55	5.25	36.4	.55	21.7	Dry $\frac{9}{10}$ NH_4Cl. $\frac{1}{10}$ NaOH.
16....	May 4	103.2	6.68	11.47	.11	22.0	NH_4Cl.
17....	May 14	105.6	6.70	11.60	.11	18.2	$\frac{9}{10}$ NH_4Cl. $\frac{1}{10}$ NaOH.
18....	May 23	107.8	6.69	11.90	.11	.....	NaOH.

NOTE.—In experiments 1–15 "Picnic Point gravel" was used, and in experiments 16, 17, 18 Madison glacial sand was used.

The water used in the experiment was obtained from Lake Mendota, Madison, Wis., and before use was freed from suspended material by passing through a filter of charcoal and sand. Before passing through the gravel in the tank, one part in 500 of 40 per cent solution of formalin was added to the water so as to inhibit the growth of organisms. Previous experimenters on the flow of water through sands and gravels experienced much difficulty on account of the progressive reduction in flow of water through the sand when an experiment extended over a considerable length of time. No means had been found for avoiding this difficulty; even the use of distilled water was not entirely effective. It was difficult to explain this phenomenon except on the basis of the growth of organisms in the pores of the

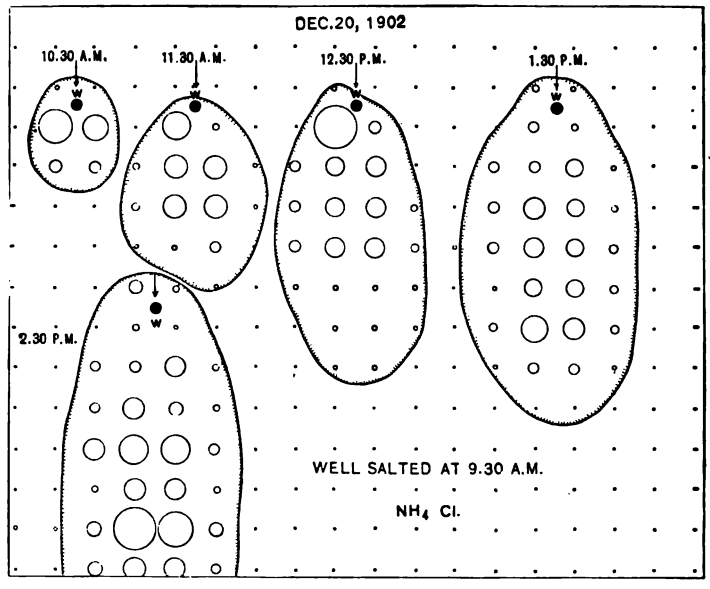


FIG. 8.—Diagram showing the manner in which the electrolyte spread in passing downstream with the ground water, in experiment 4, in the horizontal tank. The dot at W shows the location of the salted well, and samples were taken from the sand from the small test wells represented by dots in the diagram. The areas of the circles are proportional to the strength of the electrolyte found at their centers. The area covered by the charged water at the time specified is shown by a roughly sketched outline. The velocity of the ground water in the direction of the arrows was 13.2 feet for twenty-four hours. Electrolyte used was sal ammoniac.

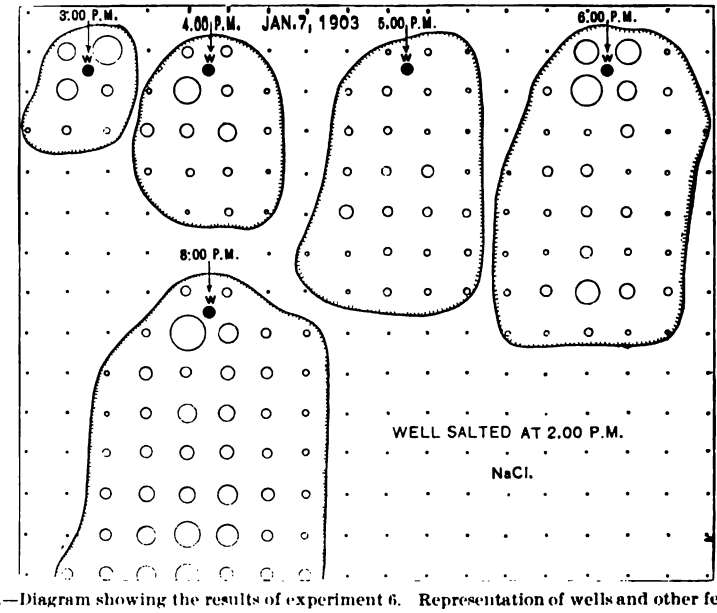


FIG. 9.—Diagram showing the results of experiment 6. Representation of wells and other features as in fig. 8. The velocity of the ground water was 12.1 feet for twenty-four hours. The electrolyte used was common salt.

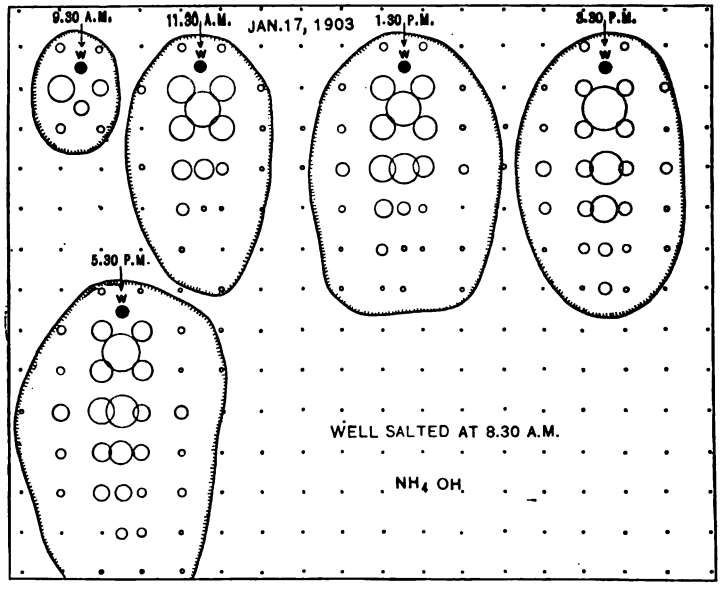


FIG. 10.—Diagram showing the results of experiment 8. Representation of wells and other features as in fig. 8. The velocity of the ground water was 9.3 feet for twenty-four hours. The electrolyte used was concentrated ammonia water.

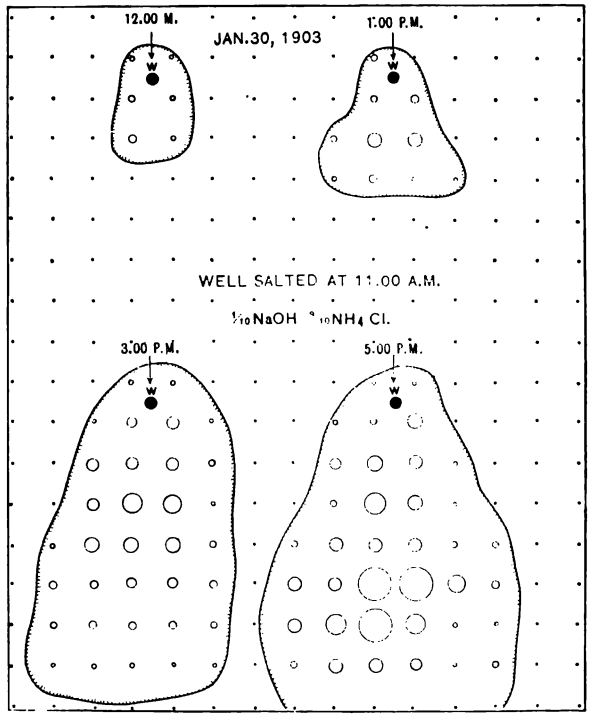


FIG. 11.—Diagram showing the results of experiment 9. Representation of wells and other features as in fig. 8. The velocity of the ground water was 11.6 feet for twenty-four hours. The electrolyte used was one-tenth caustic soda and nine-tenths sal ammoniac.

sand used in the experiments. For this reason the formalin was added to the water in the hope that if this were the correct explanation the difficulty would vanish. Several experiments were made for the especial purpose of determining the effect of the formalin in inhibiting the organic growth in the filter. Table VII gives the result of three such experiments. The duration of each experiment was divided into two nearly equal periods, and the average head of water as shown by the gages and the average flow of water, as determined by weighing both the water admitted to the tank and the water leaving it at the

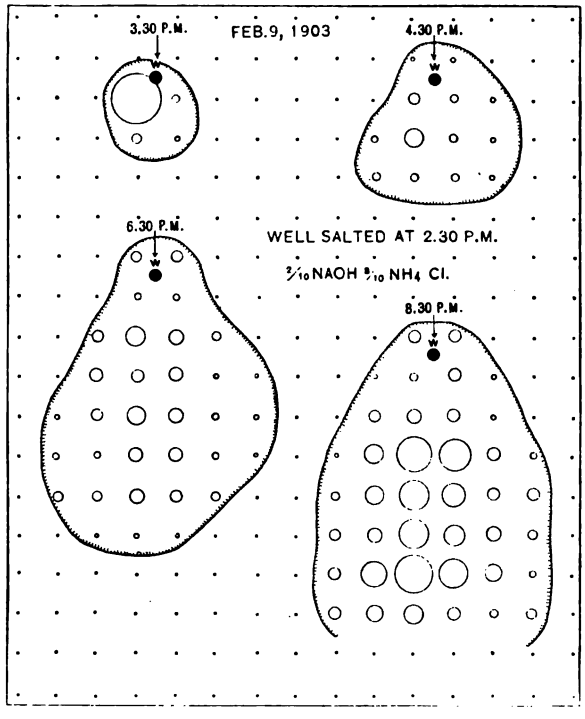


FIG. 12.—Diagram showing the results of experiment 10. Representation of wells and other features as in fig. 8. The velocity of the ground water was 11¼ feet for twenty-four hours. The electrolyte was two-tenths caustic soda and eight-tenths sal ammoniac.

lower end, were determined for each of the two periods into which each experiment was divided. It will be seen by consulting column 4 of the table that the flow of water per unit head during the first portion of each experiment was essentially identical per unit head to the second portion of each experiment. The slight differences in the numbers is much smaller than the unavoidable experimental error. It was concluded, therefore, that the progressive clogging of a sand filter is due to the growth of organisms, and that the formalin added constituted an effective remedy.

Altogether 18 experiments were carried out in this tank. In th first 15 tests Picnic Point gravel was used in the tank; during the la 3 fine glacial sand replaced the Picnic Point gravel. The glacial sa had effective size of grain, as determined by King's aspirator, d 0.40 mm. A mechanical analysis of the sand is given in Table VI

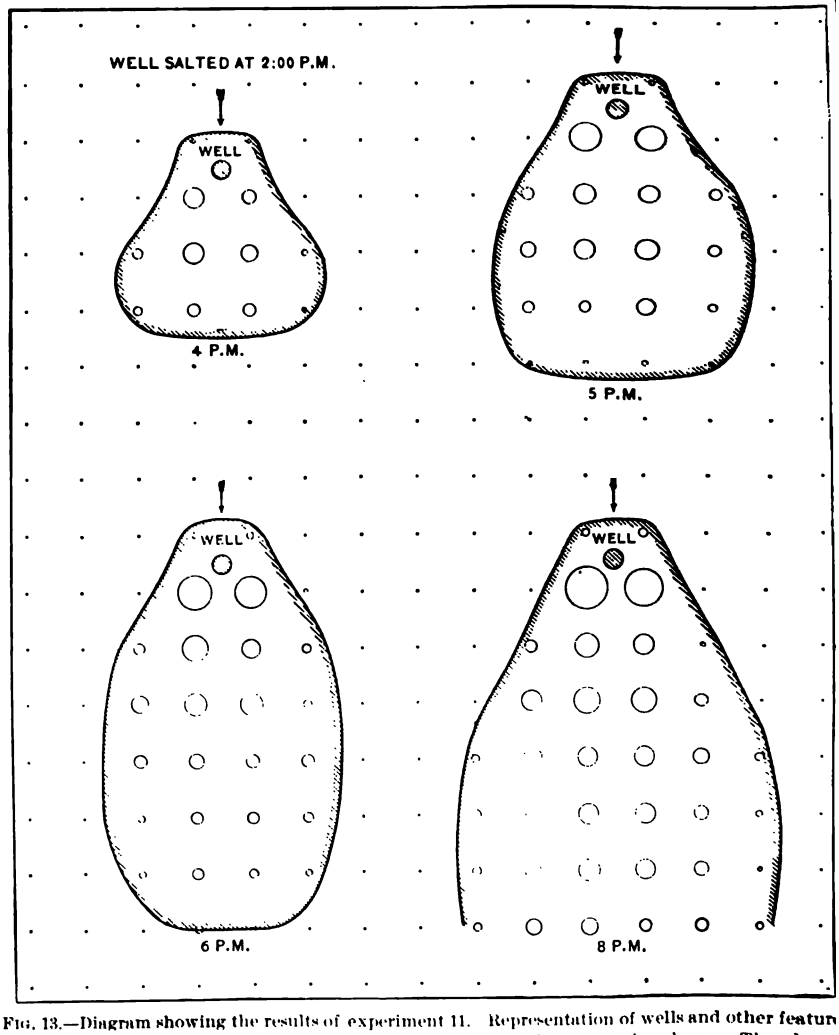


FIG. 13.—Diagram showing the results of experiment 11. Representation of wells and other featur as in fig. 8. The velocity of the ground water was 11.7 feet for twenty-four hours. The electr lyte was sal ammoniac in concentrated solution.

(p. 30), and a summary of the data obtained during the experiment is placed in Table VIII.

No difficulty was experienced in maintaining very low gradients t the water plane in the tank, a slope of water of 18 feet to the mil being easily brought about by proper adjustment in the apparatus In this way actual field conditions of the flow of water were ver

closely approximated, and velocities less than 10 feet a day could be maintained by the use of the low gradients. The large well marked W was designed to receive various electrolytes while the water was moving through the gravel under the selected uniform head. The small one-half inch wells placed at the corners of the 6 inch squares were designed to serve as test wells from which samples of the water could be taken at stated intervals, and the exact area spread over by the electrolyte could be ascertained by chemical analyses. A series of pipettes were coupled together in such a way as to permit the taking of a sample from each row of test wells at the same time. By the use

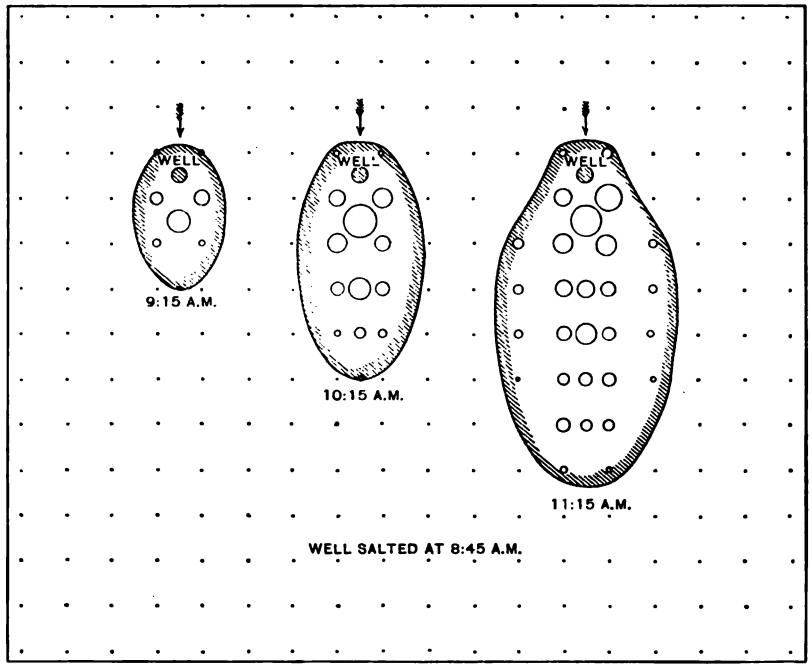


FIG. 14.—Diagram showing the results of experiment 12. Representation of wells and other features as in fig. 8. The velocity of the ground water was 21.7 feet for twenty-four hours. The electrolyte was sal ammoniac in concentrated solution.

of this device a complete set of samples could be taken from all the test wells in the tank in a very few minutes.

The results of the experiments are best shown by the series of diagrams figs. 8 to 20, in which the strength of the electrolyte found at each test well is shown by a circle of appropriate size.

Among the various electrolytes tested were ammonium chloride (sal ammoniac), sodium chloride (common salt), concentrated ammonia water, and mixtures of ammonium chloride and caustic soda, or lye. One of the most remarkable conclusions from the experiments was that diffusion plays but a very small part in the spread of the electrolyte through the ground water. In none of the experiments was it found

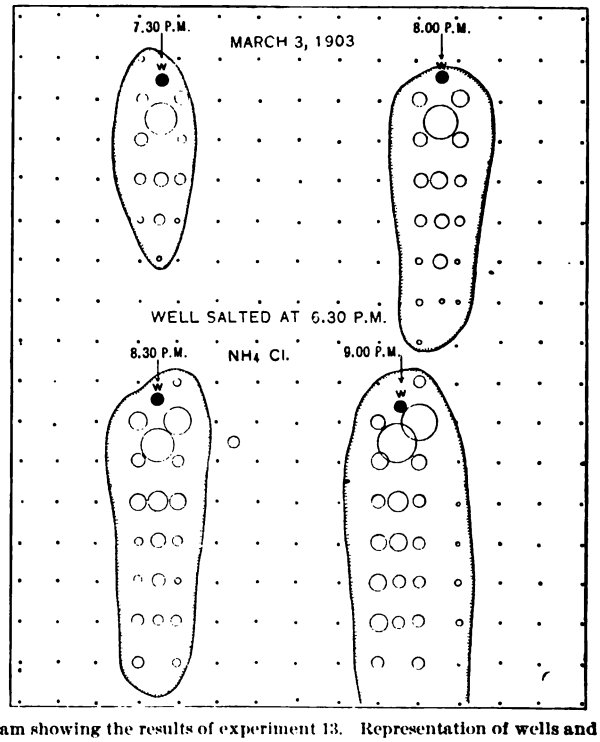


FIG. 15.—Diagram showing the results of experiment 13. Representation of wells and other features as in fig. 8. The velocity of the ground water was 36 feet for twenty-four hours. The electrolyte was sal ammoniac in concentrated solution. Note the narrow stream of electrolyte due to the high velocity.

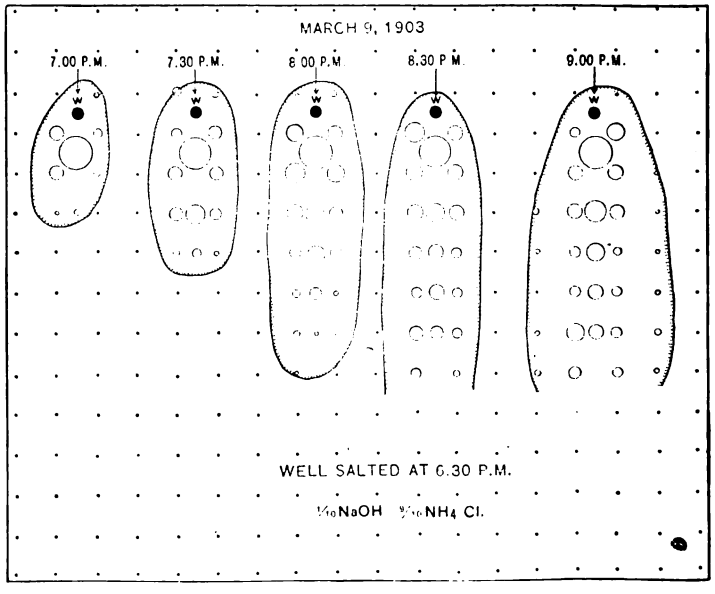


FIG. 16.—Diagram showing the results of experiment 14. Representation of wells and other features as in fig. 8. The velocity of the ground water was 35½ feet for twenty-four hours. The electrolyte was one-tenth caustic soda and nine-tenths sal ammoniac in solution.

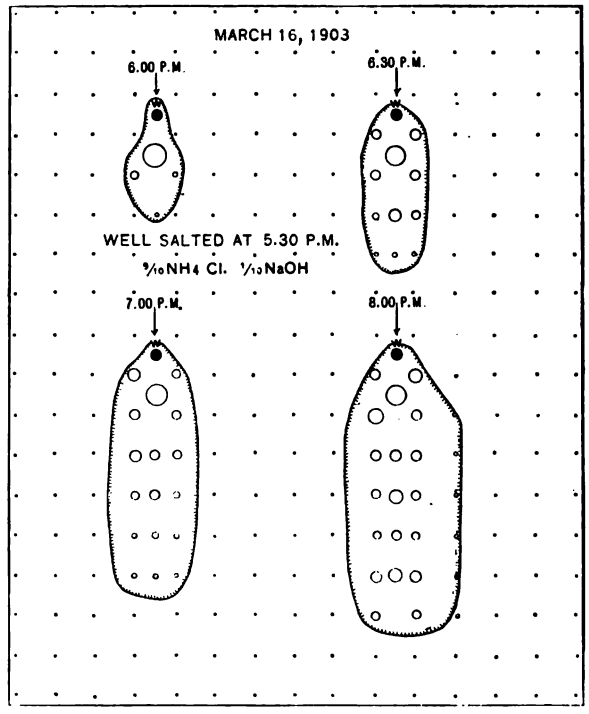


FIG. 17.—Diagram showing the results of experiment 15. Representation of wells and other features as in fig. 8. The velocity of the ground water was 36.4 feet for twenty-four hours. The electrolyte was one-tenth caustic soda and nine-tenths sal ammoniac in dry crystals.

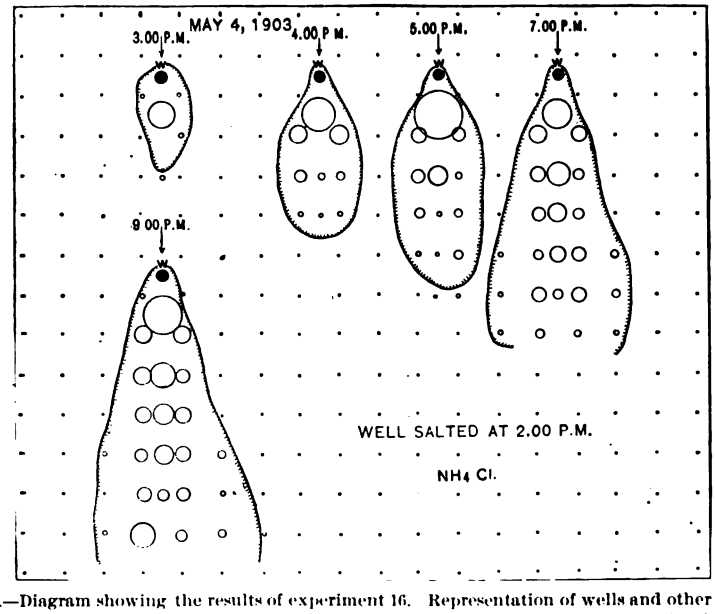


FIG. 18.—Diagram showing the results of experiment 16. Representation of wells and other features as in fig. 8. The velocity of the ground water was 11.5 feet for twenty-four hours. The electrolyte was sal ammoniac.

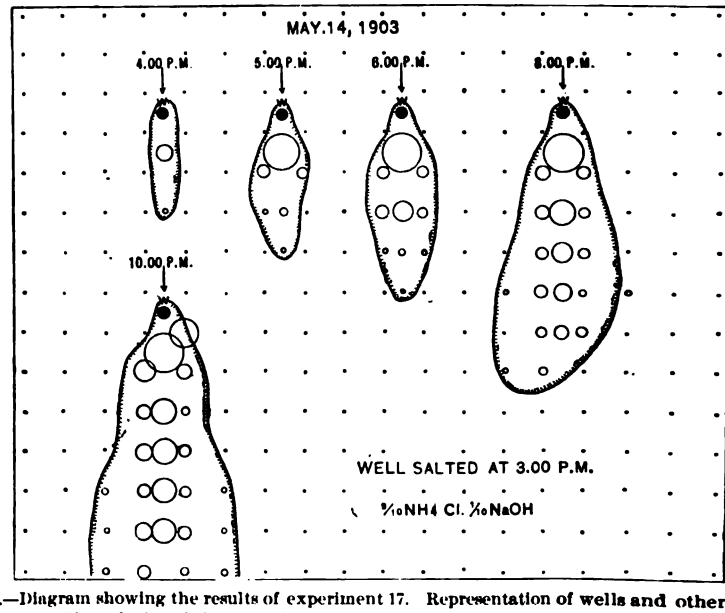


FIG. 19.—Diagram showing the results of experiment 17. Representation of wells and other features as in fig. 8. The velocity of the ground water was 11.6 feet for twenty-four hours. The electrolyte was one-tenth caustic soda and nine-tenths sal ammoniac.

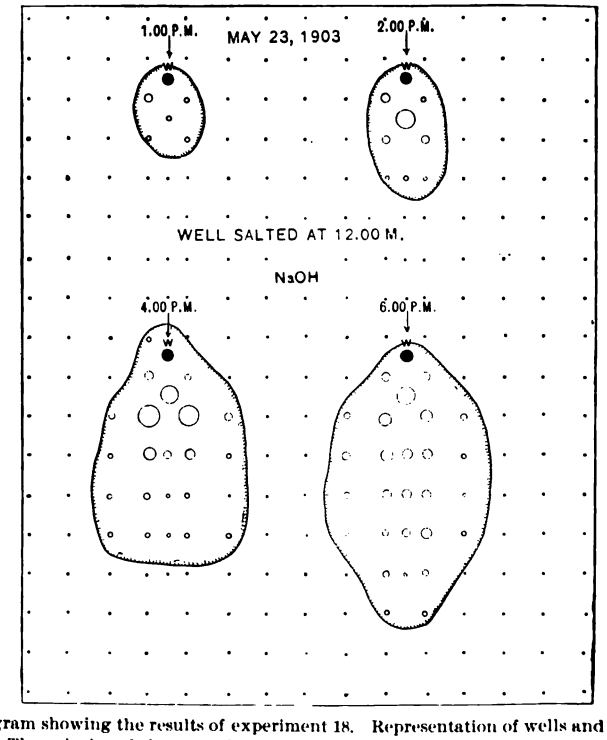


FIG. 20.—Diagram showing the results of experiment 18. Representation of wells and other features as in fig. 8. The velocity of the ground water was 11.9 feet for twenty-four hours. The electrolyte was caustic soda.

that the electrolyte extended more than about 3 inches upstream from the large well W. This fact can be seen by consulting the series of diagrams illustrating the distribution of electrolyte. In general, it can be seen that the electrolyte moves downstream in a pear-shaped mass, the width of the stream varying somewhat with the nature of the electrolyte used. The high velocities always gave a stream of electrolyte which was quite narrow and the low velocities gave broader streams. The solution of concentrated ammonia water gave the broadest stream. This was probably due not so much to the diffusion of the ammonia gas in the water as to the low coefficient of viscosity of the ammonia water. Experiments in the field had indicated that the mixture of sal ammoniac and caustic soda would spread in a broader stream than sal ammoniac alone. By comparing the results of experiments 14 and 15 with that of experiment 13, it will be seen that this assumption could not be verified to any considerable extent. In a similar way, experiments 9 and 10 may be compared with experiment 8, and experiments 17 and 18 may be compared with experiment 16.

It seems to be conclusively shown by these experiments, as has been already stated (pp. 22–23), that the diffusion of the dissolved salt plays a very small part in the way in which the electrolyte is distributed in the moving current of ground water, but, as already stated, that the central thread of water in each capillary pore of the soil moves faster than the water in contact with the walls of the capillary pore. Likewise the spread of the electrolyte, as shown by these experiments, is not to be explained by the diffusion of the salt, but must be explained by the continued branching and subdivision of the capillary pores around the individual grains of the sand. The stream of electrolyte issuing from the salt well W will gradually broaden as it passes downstream, because each thread of it must divide and divide again and again as it meets with each succeeding grain of soil. If diffusion had much to do with its rate of spread, it would also make itself apparent by causing an upstream motion to the electrolyte against the current of ground water. As before stated, in no case did the electrolyte succeed in moving upstream a distance as great as 3 inches.

EXPERIMENTS IN THE VERTICAL TANK.

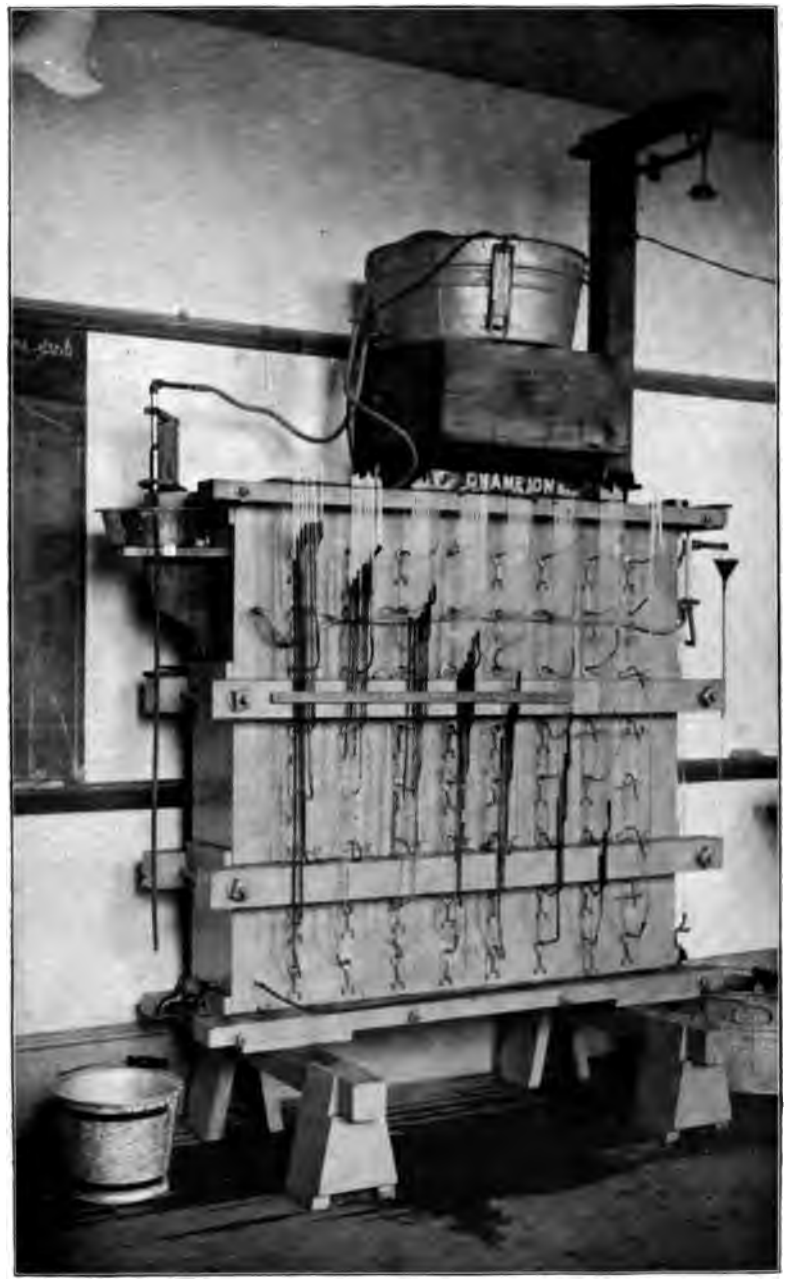
The experiments carried on in the winter of 1903–4 had as their object, in addition to those of the previous year, the determination of the law of distribution of the electrolyte in a vertical plane. For this purpose a tank was constructed of wood, as shown in fig. 21 and Pl. VIII. The inside dimensions of this tank were 4 feet high, 4 feet 6 inches long, and 8 inches wide. At each end of the tank chambers 3 inches wide were constructed of perforated brass, similar to those

used in the horizontal tank, leaving a total length of 4 feet available for gravel. Horizontal tubes of slotted brass one-half inch in diameter extended through the side of the tank at the corners of squares 6 inches on a side, as shown by the small circles in the side elevation, fig. 21. These tubes of horizontal test wells were stuck through holes bored in the side of the tank and were supported at one end by a thumb tack soldered to the end of the tube and at the other end by the side of the tank, the tube being slightly longer than the inside width of the tank. A perforated rubber stopper containing a glass tube was placed in the hole, one end of the glass tube extending to the middle of the tank, the other end of the tube projecting outside of the rubber stopper to receive a small rubber tube, which was kept closed by means of a pinchcock. These tubes furnished ready means of drawing out samples of water from different positions in the tank. On top of the tank, in the reproduction of the photograph of the apparatus, Pl. VIII, can be seen the scales carrying the tubs of galvanized iron from which the water was run to a regulating apparatus consisting of a needle valve and float at the upper left-hand corner of the box similar to that used in the horizontal tank. The head of water in the two end chambers of the tank was measured by two glass gages placed about one-half inch apart, communicating with the chambers by large rubber tubes. The readings of the meniscus in the glass tubes of the gages could be readily estimated to one-half hundredth of an inch.

The gravel used in the experiments in the vertical tank was Madison glacial sand, the same as that used in experiments 16, 17, and 18 in the horizontal tank. Seven experiments were completed with this apparatus, the general results of which are tabulated in Table IX.

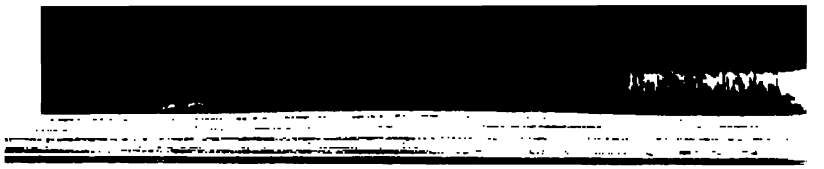
TABLE IX.—*Data obtained during experiments on flow of water through Madison glacial sand in the vertical tank.*

	Date.	Temperature.	Hydraulic gradient.		Discharge.		Area of cross section.	Velocity.	Velocity per unit head.
	1904.	*° C.*	*Per cent.*	*Feet per mile.*	*Pounds per hour.*	*Cubic feet per minute.*	*Square feet.*	*Feet per diem.*	*Feet per diem.*
1	Feb. 22	17.8	3.10	164	36.25	0.00965	2.34	16.90	0.10
2	Mar. 2	19.2	2.08	110	26.53	.00706	2.54	11.42	.10
3	Mar. 3	14.0	5.41	286	56.00	.0149	2.50	24.50	.09
4	Mar. 5	18.4	1.00	53	9.94	.002645	2.56	4.28	.08
5	Mar. 12	16.0	2.10	112	23.36	.00622	2.54	10.10	.09
6	Apr. 18	14.9	11.91	630	129.66	.0346	2.42	58.80	.09
7	Apr. 19	17.0	5.58	295	51.68	.0138	2.50	22.70	.08



VERTICAL TANK USED IN LABORATORY EXPERIMENTS.

The small test wells from which samples were drawn are equipped with glass gauges containing colored water, indicating distribution of pressure while right chamber of tank is kept empty.



The electrolyte was introduced into the well marked W, shown in fig. 21, and the samples from the various test wells were drawn out at stated intervals into test tubes and analyzed. The results of the

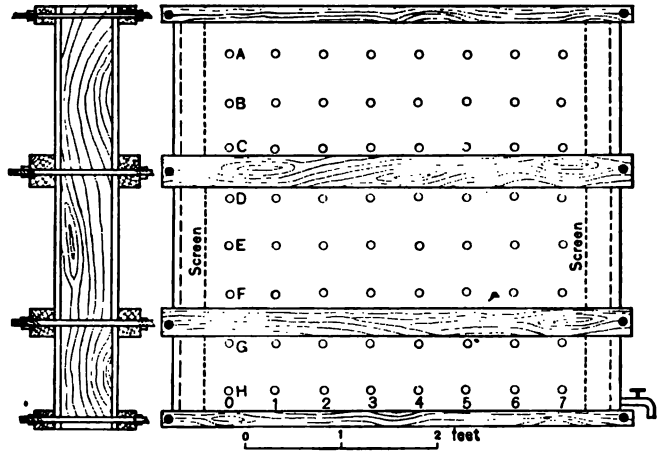


FIG. 21.—Diagram showing construction and dimensions of vertical tank used in laboratory experiments on the flow of ground water. The small circles indicate the position of the test wells.

experiments on the vertical distribution of the electrolyte are best shown by the diagrams, a series of which are given in figs. 22 to 29.

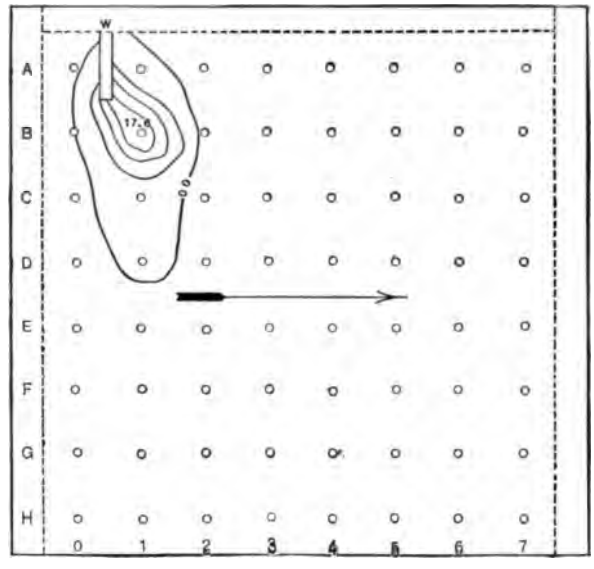


FIG. 22.—Diagram showing results of vertical-tank experiment 1, February 22, 1904. Well W was salted at 11.40 a. m. with sal ammoniac; velocity of the ground water was 17.06 feet a day, head, 1¼ inches. The contours show the distribution of salt at 12.10 p. m.

In the series of six diagrams for experiment 1 the distribution of the electrolyte is shown by the contour curves for each one-half hour

period after the beginning of the experiment. A single dose of 2 ounces of sal ammoniac was introduced into the well W at 11.40 a. m.,

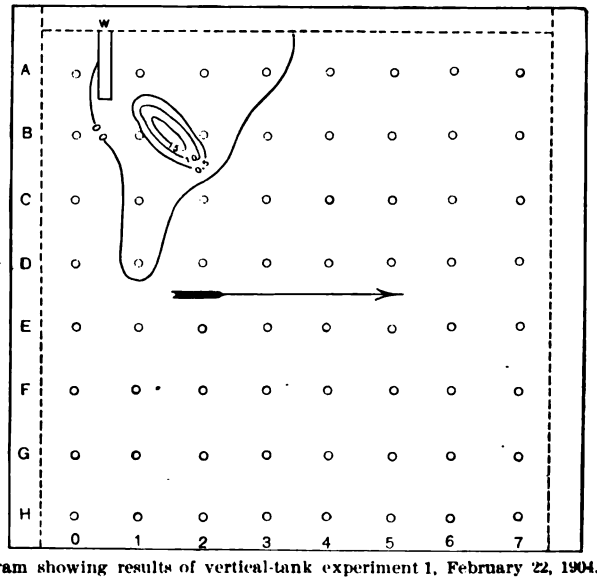


FIG. 23.—Diagram showing results of vertical-tank experiment 1, February 22, 1904. Well W was salted at 11.40 a. m. with sal ammoniac; velocity of the ground water was 17.06 feet a day; head, 1¼ inches. The contours show the distribution of salt at 12.40 p. m.

on February 22, 1904. As will be observed by consulting the diagrams, the dissolved salt entered the ground water and passed to the

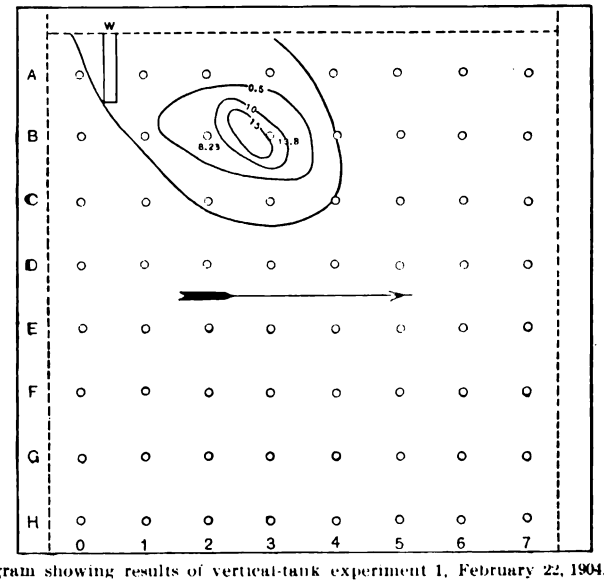


FIG. 24.—Diagram showing results of vertical-tank experiment 1, February 22, 1904. Well W was salted at 11.40 a. m. with sal ammoniac; velocity of the ground water was 17.06 feet a day; head, 1¼ inches. The contours show the distribution of salt at 1.40 p. m

right with the moving stream, at the same time moving slightly downward, as shown by the contour curves. The velocity of water through

the gravel during this experiment was about 17 feet for twenty-four hours. The elliptical outline of the contour curves is due to the two

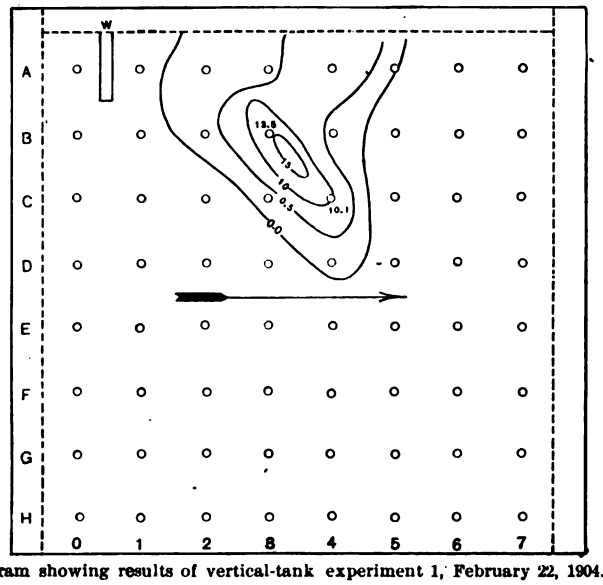


FIG. 25.—Diagram showing results of vertical-tank experiment 1, February 22, 1904. Well W was salted at 11.40 a. m. with sal ammoniac; velocity of the ground water was 17.06 feet a day; head, 1¼ inches. The contours show the distribution of salt at 2.40 p. m.

components of motion, one component being the velocity of ground water to the right, and the other being the downward motion, due to

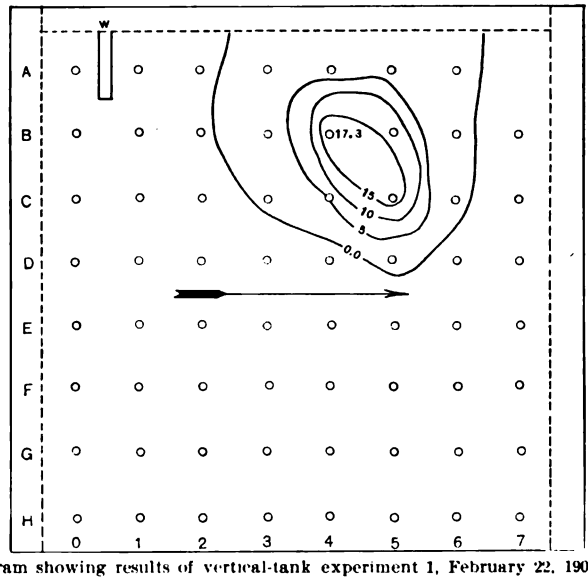


FIG. 26.—Diagram showing results of vertical-tank experiment 1, February 22, 1904. Well W was salted at 11.40 a. m. with sal ammoniac; velocity of the ground water was 17.06 feet a day; head, 1¼ inches. The contours show the distribution of salt at 3.40 p. m.

the high density of the solution of sal ammoniac. It will be noticed that the elliptical contour lines have their longest dimension sloping

downward to the right, as they should if they represent the resultant of these two motions. It should also be noted (consult the diagrams)

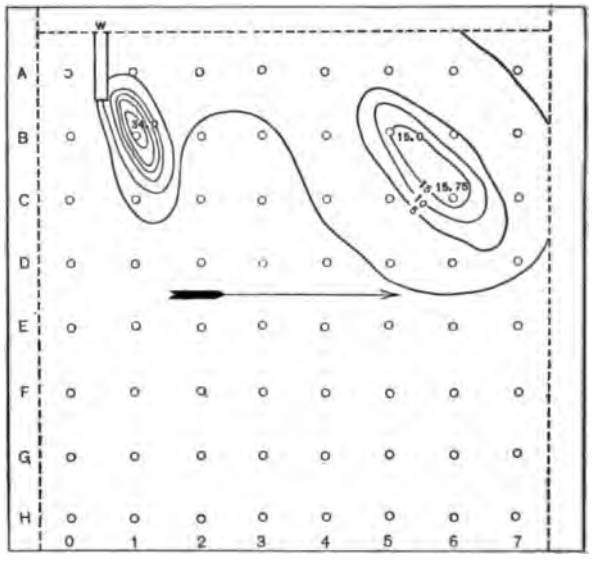


FIG. 27.—Diagram showing results of vertical-tank experiment 1, February 22, 1904. Well W was salted at 11.40 a. m. with sal ammoniac; velocity of the ground water was 17.06 feet a day; head, 1¼ inches. The contours show the distribution of the salt at 4.40 p. m. A second dose of salt was placed in well W at 4 p. m., and the diagram represents the two masses of electrolyte passing forward with the ground water

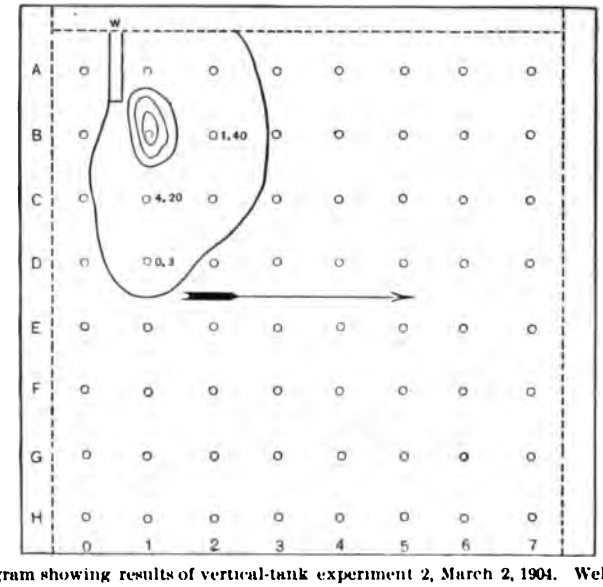


FIG. 28.—Diagram showing results of vertical-tank experiment 2, March 2, 1904. Well W was salted at 2.25 p. m. The velocity of ground water was 11.42 feet a day; head, 1 inch. The salt used was sal ammoniac. Contours show the distribution of salt at 2.55 p. m.

that after an interval of an hour nearly all of the electrolyte had left well W, and the water in the well had become fresh again. At 4 p. m.

an additional dose of sal ammoniac was placed in well W, the effect of which is clearly shown in the contour curves for 4.40 p. m. Here two masses of dissolved electrolytes can be observed traveling simultaneously through the sand. It should also be noted in these diagrams that the electrolyte does not pass upstream, or against the current of ground water more than 1 or 2 inches.

Two sets of contour curves are also given for the second experiment, that of March 2, 1904, in which the same electrolyte was used, but the velocity of the ground water was reduced to 11.42 feet for twenty-four hours. The well W was salted at 2.25 p. m., contours being given for 2.25 and 7.25 p. m. It will be observed that for the lower velocity of ground water the electrolyte sinks to a greater depth than in the case

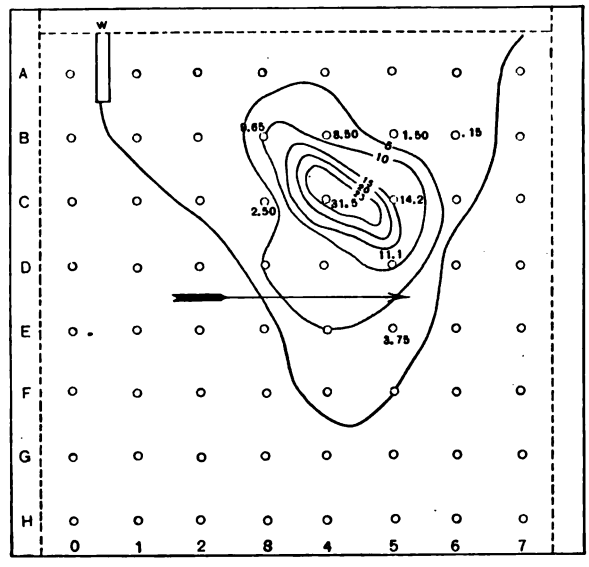


FIG. 29.—Diagram showing results of vertical-tank experiment 2, March 2, 1904. Well W was salted at 2.25 p. m. The velocity of ground water was 11.42 feet a day; head, 1 inch. The salt used was sal ammoniac. The contours show the distribution of salt at 7.25 p. m. A comparison of figs. 28 and 29 with 22 to 27 shows the larger vertical motion of the electrolyte, in the case of the lower velocity of experiment 2, as compared with the higher velocity prevailing during experiment 1.

of the higher velocities of the first experiment. Experiments were also carried out with common lye as electrolyte. This salt is very much heavier than sal ammoniac, and it was noted that it sank much faster than the solution of sal ammoniac for similar velocities of ground water.

One of the most interesting experiments with the vertical tank was made for the purpose of determining the amount of diffusion of the electrolyte. For this purpose the electrolyte was introduced into the well W and the ground water was permitted to remain stationary, no water being run into or out of the tank during the eight hours covered by the experiment. The well W is placed exactly midway between

columns 0 and 1 of the small test wells, as can be seen from the diagram. For the purpose of the "still" experiment the uppermost test well of column 2 was removed and well W was placed directly over column 2. A charge of salt was introduced into the well W at 9 a. m., and samples were taken at the end of one-half hour and at the end of each hour thereafter until 5 p. m. The salt was found to drop vertically with a rapidity equal to the vertical component of motion noted in the experiments in which flow took place. In the eight hours of the test no portion of the charge could be detected in the test wells of columns 1 or 3. This experiment showed that the electrolyte had not

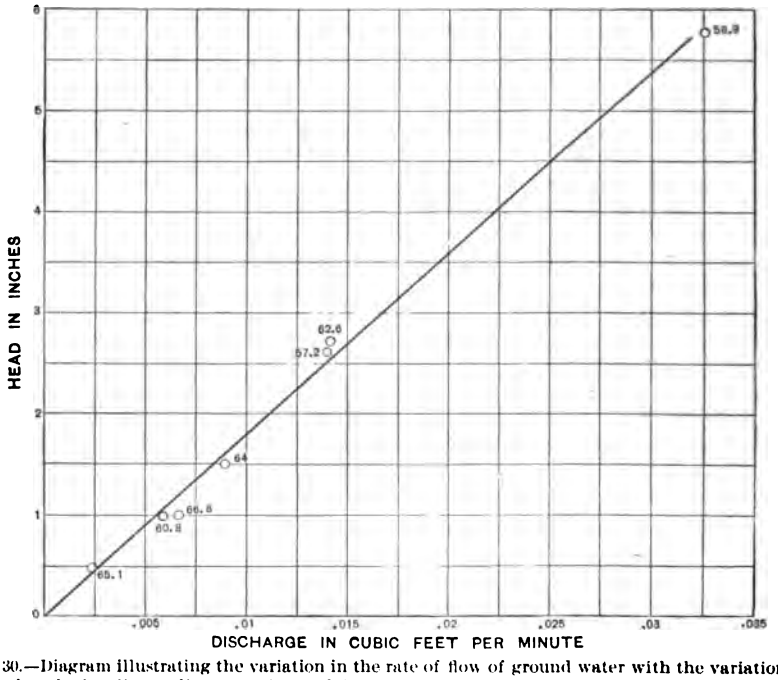


FIG. 30.—Diagram illustrating the variation in the rate of flow of ground water with the variation in head or hydraulic gradient, as observed in the experiments in the vertical tank. The figures attached to the small circles in the diagram designate the temperature, Fahrenheit, of the ground water during the experiment. The straight line represents the theoretical law of flow if the rate of flow varies directly as the head.

diffused sufficiently to reach the wells of columns 1 and 3, while dropping a vertical distance of about 3 feet.

The law of direct variation of the flow of ground waters with the head under which the flow takes place are verified by the experiments in the tank. The results are represented graphically in fig. 30. Exact agreement with this law would require all of the plotted points in this diagram to lie upon the straight line, provided the temperatures were the same. The larger departures from the straight line are not due to temperature differences, but to the high viscosity of the lye solutions used in those particular experiments,

INVESTIGATION OF THE ACCURACY OF THE ELECTRIC METHOD OF DETERMINING THE VELOCITY OF THE FLOW OF GROUND WATERS.

The vertical tank offered a ready means of checking the accuracy of the method of measuring the velocity of ground waters with the electric underflow meter. For this purpose the chambers of perforated brass at the upper and lower ends of the tank served as the upstream and downstream wells, respectively, and an electrode was sunk in the sand 2 inches from the lower partition, which answered the purpose of the electrode usually placed inside the downstream well. The apparatus was then connected in accordance with the method used in actual field work. A solution of sal ammoniac was placed in the upper chamber. The water running through the tank was weighed before it entered and after it left the apparatus, and observations were made of the electric current every fifteen minutes and sometimes oftener. Two experiments were made, one with a head of water of 2.68 inches and one with a head of 5.75 inches. From the weight of water discharged the computed velocity during the former was 23.15 feet a day, and during the latter the velocity was 58 feet a day. From the points of inflection of the two electrode curves the velocities were computed to be, respectively, 23.25 and 64.10 feet a day. This shows agreement in the case of the lower velocity within a very small fraction of 1 per cent, and in the case of the higher velocity within 10½ per cent of the actual rates. These results show that the electric method is sufficiently accurate for the purposes for which it is intended. It is very likely that if the tank in which these experiments were carried out had been wider the percentage agreement for the high velocity would be even closer than 10 per cent, for it must be remembered that the narrowness of the tank tended to bring the concentrated portion of the stream of electrolyte to a given downstream point more rapidly than if the tank had been wide enough to permit the electrolyte to spread in its natural way.

CHAPTER IV.

MEASUREMENTS OF THE UNDERFLOW AT THE NARROWS OF THE RIO HONDO AND SAN GABRIEL RIVER, CALIFORNIA.

The following underflow measurements were made during the summer of 1902 at the narrows of the Rio Hondo and the San Gabriel River, about 10 miles east of Los Angeles, Cal. The ultimate source of the streams referred to is found in the San Gabriel Mountains, a range which runs nearly east and west about 40 or 50 miles from the southern coast line of California. The main portion of the mountain drainage which supplies this particular stream is collected into one of the large canyons of the range, known as the San Gabriel Canyon. Like that of other streams that originate in these mountains, the water is not carried above ground much farther than the mouth of the canyon, except in times of extreme flood. The ordinary flow of the river sinks into an enormous alluvial delta cone of gravel and mountain débris, and passes underground in a broad, gently sloping valley until it is interrupted by a line of shale hills about 10 miles south of the mountain range. This line of hills acts as a dam to the underground waters, except for a break about 2 miles in width, where the drainage of the valley escapes to the sea. This break constitutes the so-called "Narrows" of the river. In consequence of the narrow outlet a large quantity of the ground water is brought to the surface, first showing itself about 2 miles above the narrows, and increasing in volume as it enters the contracted part of the pass. At the present time the surface waters appear as two distinct streams, the Rio Hondo on the west side and the San Gabriel River on the east side of the narrows.

In August, 1900, the flow of the Hondo at Old Mission bridge was 23 second-feet. The flow of the San Gabriel was somewhat larger. The Whitney electrolytic bridge indicates that the ground water and surface waters are substantially identical in character, containing 15 to 25 parts per 100,000 total solids.

The measurements of the rate of underflow were made by the electrical method as previously described in this paper. At the time of making these measurements the recording instruments had not been perfected for field use, so that all of the work was done with the hand apparatus. The test wells used were 2-inch drive wells, with 42-inch

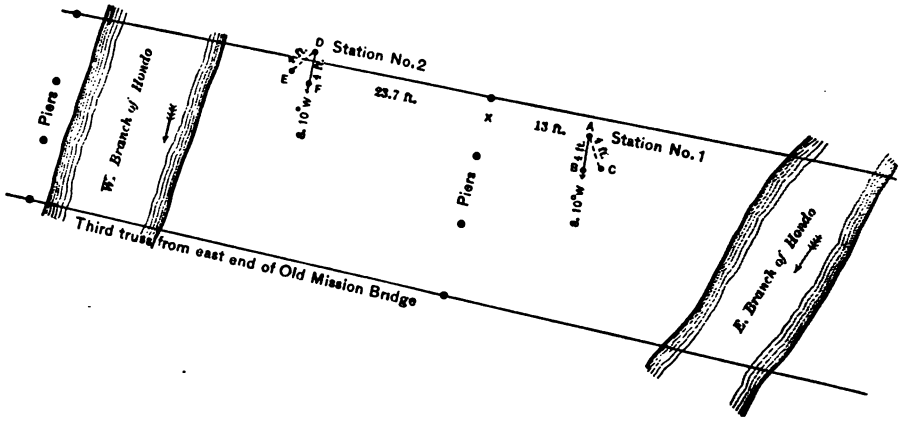
points and 48-inch well-point extensions. The wells were arranged as usual, one upstream, designed to receive the electrolyte, and the others downstream, 2 feet apart on an arc of a circle of 4-foot radius. In most instances the electrolyte moving with the ground water would show itself at but one of the downstream wells, but in one or two cases it reached two of the downstream wells, and in a few cases the first setting of the wells did not correspond to the actual direction of the motion, so that the lower wells were not touched at all by the dissolved electrolyte.

Measurements were made at four stations located within the narrows of the rivers named. The first and second stations were located under a wagon bridge over Rio Hondo near the Old Mission. Two groups of wells were driven, and the location and direction of these wells with reference to the bridge are shown in fig. 31. The electrical current was observed separately for a circuit between the casing of the upstream well and the casing of each of the downstream wells, and also for the circuit between the casing of each downstream well and the brass rod electrode contained within it, a direct-reading ammeter being used. The velocity at the first station was 3.8 feet per diem. The direction of flow departed slightly from the direction of the surface river, being 10 degrees west of south.

At the second station the electrolyte showed itself at both of the downstream wells, being stronger, however, in well F. The velocity here was 6.6 feet a day. Points of special interest are the several steps in which the ampere curves rise, as shown on the electrode circuits for both wells E and F. These indicate different velocities of ground water in the different strata penetrated by the wells. The well points and well-point extensions being covered with new bright brass gauze in these first tests, the different porous strata registered themselves on the brass gauze by blackened bands caused by the corroding influence of the electrolyte. In the present case there were three distinct zones marked off on the wells, of about 24, 20, and 8 inches each. The velocities in these strata undoubtedly differed from one another, and hence caused the steps in the ampere curve. At both stations 1 and 2 the ground water was artesian in character, rising in the wells about an inch for each additional foot increase in depth. The wells were 16 feet deep and showed about 15 inches of artesian head above the water in the flowing stream.

The third station was established on the San Gabriel River just below the wagon bridge on the Whittier road. A special point of interest at this location is the fact that the river totally disappears in its gravel bed a few rods below this bridge. We hoped to secure some facts concerning the direction and velocity of the disappearing water. A double row of wells was driven across the river bed in the

groups about 33 feet apart, as shown in fig. 32. All of the wells, except a group near the left bank, pumped very poorly and were evidently in very tight material. The group of wells near the left



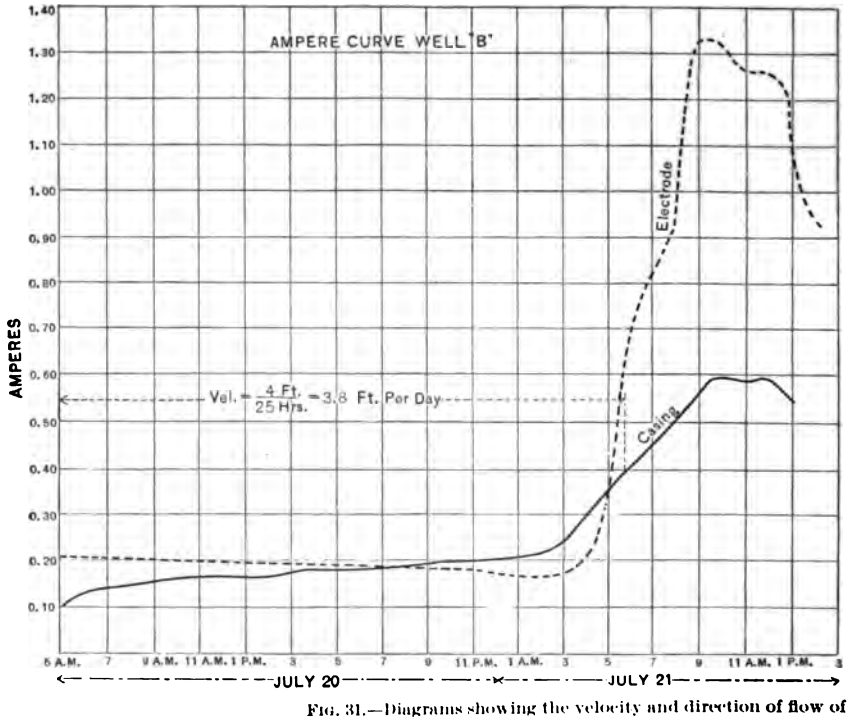


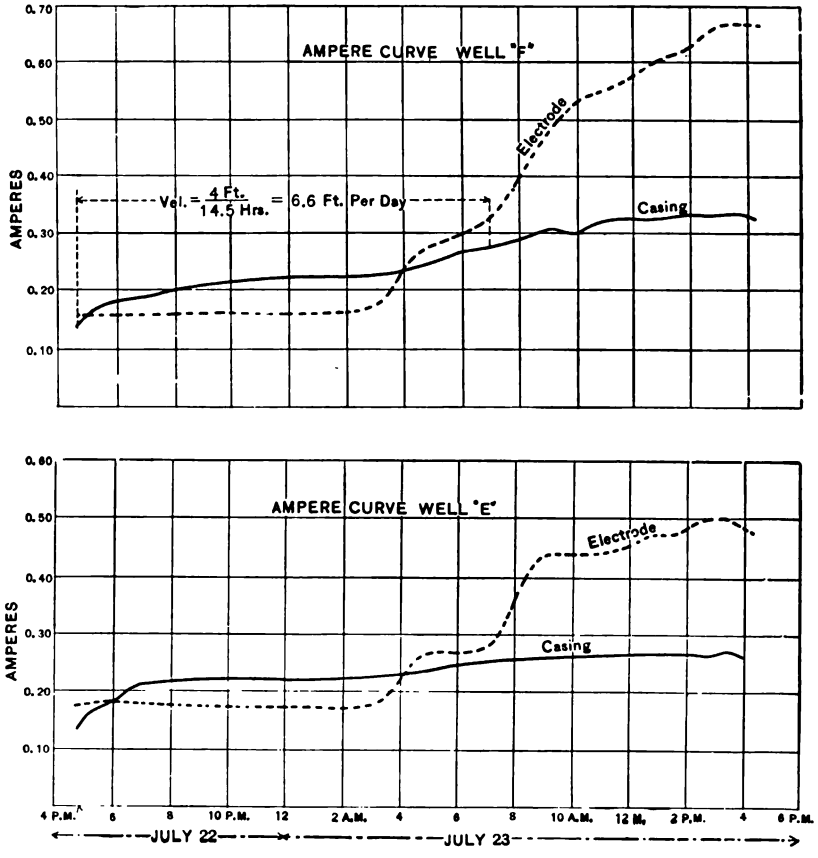
FIG. 31.—Diagrams showing the velocity and direction of flow of the

bank consisted of one upstream well, E, and two downstream wells, F and G. These wells evidently penetrated two different strata of water, as a velocity of 48 feet a day was observed between E and F,

while a second result was strongly developed, indicating a velocity between E and G of 4.8 feet a day. This latter rate was due to the lower stratum of water, whose direction of motion crossed at an angle of 35° that of the upper current of disappearing river water. Further observations at this point were rendered impossible by the breaking of a dam some distance above the station, which completely flooded the wells after the above observations had been made.

The fourth station was established in a walnut grove on Temple's ranch, near the main road from El Monte to Downey. This location is about half way between the two bluffs of the narrows. The group consisted of four wells, and a velocity was found to be rather low, 14 inches a day. The direction of flow was due south.

The fifth station was on the bank of the San Gabriel River, just



underground water at the narrows of the Rio Hondo, stations 1 and 2.

above the head works of the Ranchita and Los Nietos ditches. The velocity determined was 5.3 feet a day, in a direction due south, making an angle, however, of about 45° with the direction of the surface

stream at the same point. The direction of flow and ampere curve are shown in fig. 4.

The cross section of the alluvial deposits at the narrows of the Hondo and the San Gabriel is about 10,000 feet wide and probably does not exceed 600 feet in depth. If we assume that the porosity of the underflow gravel is 33 per cent and that the average velocity of the ground water is 10 feet a day, the resulting estimate of the amount of water which passes underground through the narrows is 230 second-feet, or nearly four times the flow of the surface streams. This is undoubtedly a maximum estimate, as there is no indication that the average velocity is as high as 10 feet a day. Four feet a day may be assumed as a fair minimum value of the average velocity. This would correspond to a total underflow of 92 second-feet.

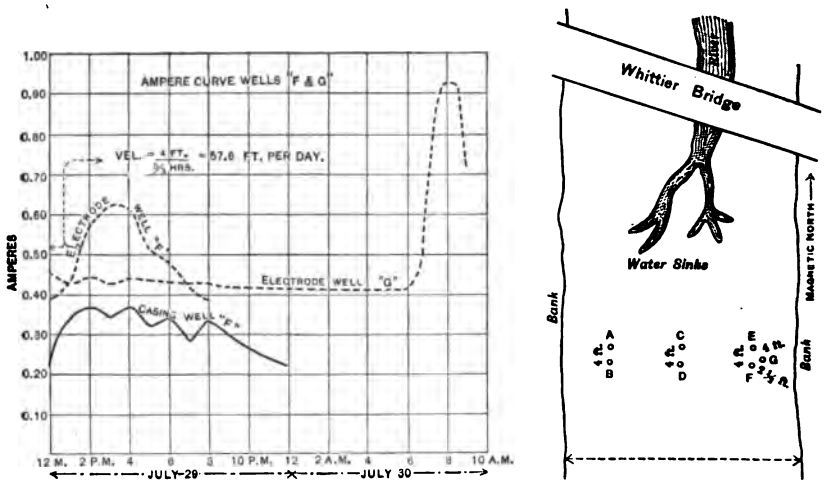


FIG. 32.—Diagram of velocity and direction of flow of underground water at the narrows of the San Gabriel River; station 3.

The measurements established the existence of a distinct underflow of moderate velocity through the alluvial deposits of the narrows. In low stages of the surface streams the underflow probably represents a drainage from the upper valley in excess of that discharged by the surface streams. The substantial identity of the water of the underflow and the water of the surface streams is proved by tests with the Whitney bridge, so that we may conclude that the original mountain stream appears at the narrows as a composite river, consisting of surface streams bordering both the east and the west bluffs of the narrows, together with a very wide and deep but slowly moving underflow occupying the entire major trough of the valley.

CHAPTER V.

MEASUREMENTS OF THE UNDERFLOW AT THE NARROWS OF THE MOHAVE RIVER NEAR VICTORVILLE, CAL.

CONDITIONS AT THE STATION.

The Mohave River rises on the slope of the Sierra Madre Mountains in San Bernardino County, Cal., its headwaters flowing from elevations of 5,000 to 8,000 feet. After following a general northerly course the stream disappears in the Mohave Desert a short distance below Barstow, Cal. After leaving its mountainous canyon the stream gradually loses water, and for a large portion of the summer its bed is dry for a greater part of its course on the plains. At a point about 16 miles north of its source the river passes through a narrow gorge called the "Narrows" of the river. The granite uplift which forms this gorge constitutes a dam that raises the underflow to the surface, so that within an area that extends from a point a mile and a half above the gorge to a point a considerably greater distance below the gorge the stream is of perennial flow. A view of the narrows of the river is shown in Pl. IX. This gorge is just south of the village of Victorville, Cal., a station on the Santa Fe Railway. The place had been under investigation as a possible site for a dam by the United States Geological Survey during the season of 1899 and previously. Reports on this subject will be found in the Eighteenth Annual Report, United States Geological Survey, Part IV, page 708, and the Twenty-first Annual Report, United States Geological Survey, Part IV, page 471. The permanent dry-season flow of the river at the gorge varies from about 30 to 60 second-feet. On August 15, 1902, the discharge, as measured by J. B. Lippincott, was 33 second-feet. Soundings have been made to bed rock at three different lines across the narrow part of the gorge by the United States Geological Survey. The positions of these cross sections are shown in fig. 33. The river-gage rod of the United States Geological Survey is located on the right bank of the river at the end of line 3. This line was selected as the location for the underflow measurements. The maximum depth to bed rock at this point is 46 feet, as is shown in the approximate cross section given in fig. 34. The material filling the gorge and constituting the bed of it is a coarse angular granite débris of a size somewhat larger than buckwheat. Mechanical analysis of the gravel filling the gorge is given in Table VI (p. 30). Determinations of

the effective size of the gravel by King's aspirator showed a mean diameter of 0.72 mm. The samples of gravel were taken from the

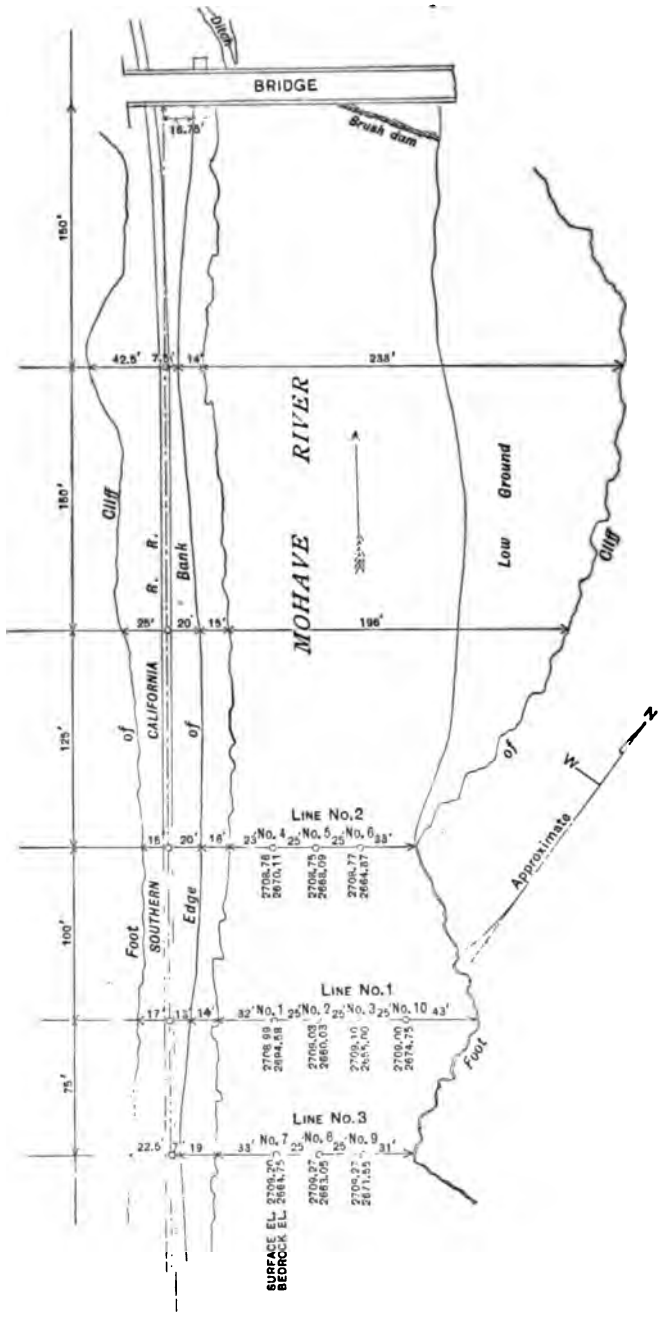
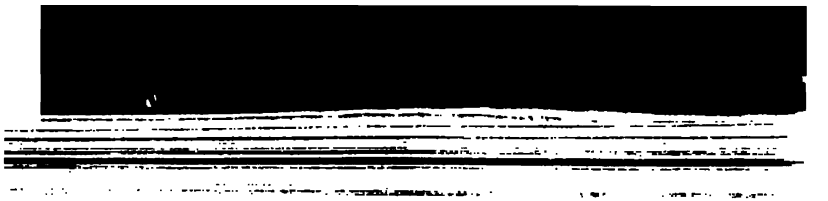


FIG. 33.—Map of the narrows of the Mohave River above Victorville, Cal., showing three lines of test borings made to bed rock by the United States Geological Survey in 1900. Line 3 of these borings coincides with the cross section at which the underflow measurements were made.

surface material. High velocities of the underflow determined at certain depths indicate that there are some streaks of coarser material.

NARROWS OF MOHAVE RIVER.

At time of the underflow investigation; instruments are located in tent at side.



DESCRIPTION OF EXPERIMENTS.

The site selected for the measurement of the underflow at the upper narrows of the river was in a line extending across the river at right angles to its main course, as shown in the plan given in fig. 33. The water in the river at this point hardly exceeded a foot in depth, but the water spread over the greater portion of the space between the banks, necessitating the construction of a small foot bridge, shown in

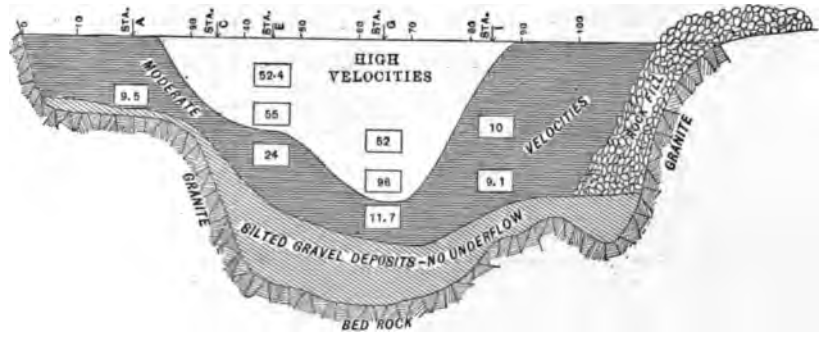


FIG. 34.—Cross section of the narrows of the Mohave River at which the underflow was measured. This line of cross section corresponds to line 3 in the preceding diagram. The rectangles inclosing the figures represent the position and depth at which the underflow was measured. The figures inclosed in the rectangles represent the velocity in feet per day at that point in the cross section.

Pl. X. Another view, Pl. XI, illustrates the method used in putting down the test wells. The double row of test wells, A, B, C, D, E, F, G, H, I, were driven across the river at this point as located on the plan shown in fig. 35. The gorge at this place is only 120 feet wide, and it was at first thought unnecessary to drive more than a single downstream well for each measurement, as it was believed that the

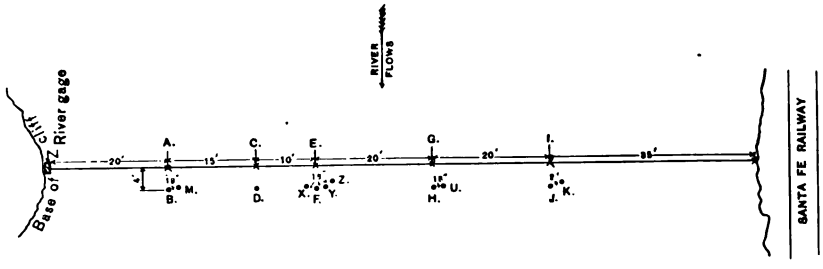


FIG. 35.—This plan shows the position of the various test wells used in the underflow investigation. The principal line of test wells corresponds to line 3 of fig. 33.

underflow must move through the gorge in a very direct course. It was determined, however, after first salting the upstream wells, that the ground waters must be moving through the gorge at this point at a slightly different direction from that of the surface waters, as absolutely no results could be obtained from the wells as first arranged. Accordingly, directional wells M, X, Y, Z, U, K were driven as

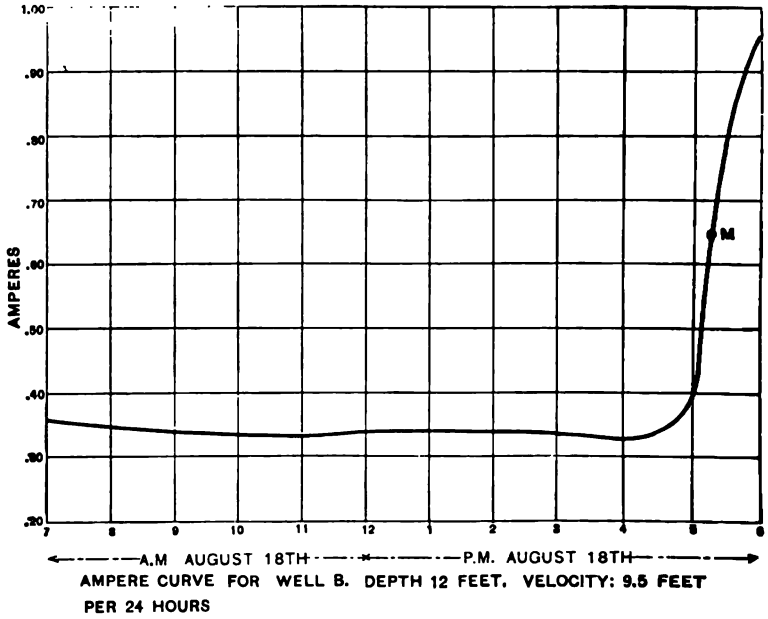


FIG. 36.—Diagram showing the velocity of underflow at narrows of **Mohave River, Station A.**

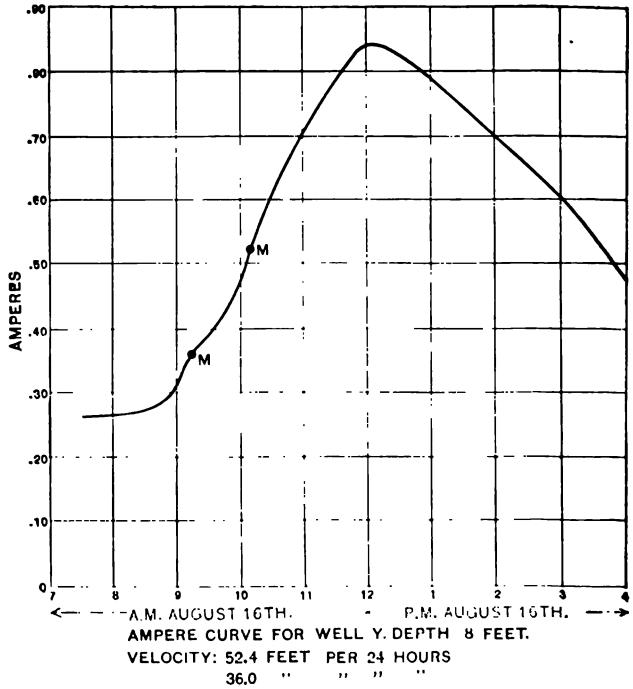
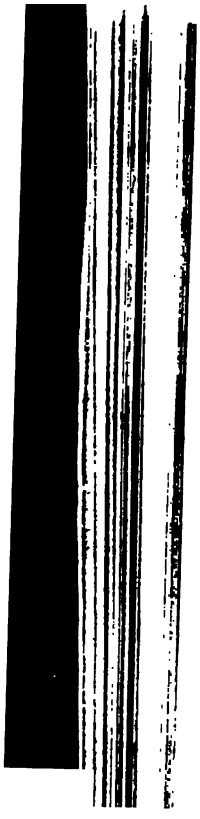
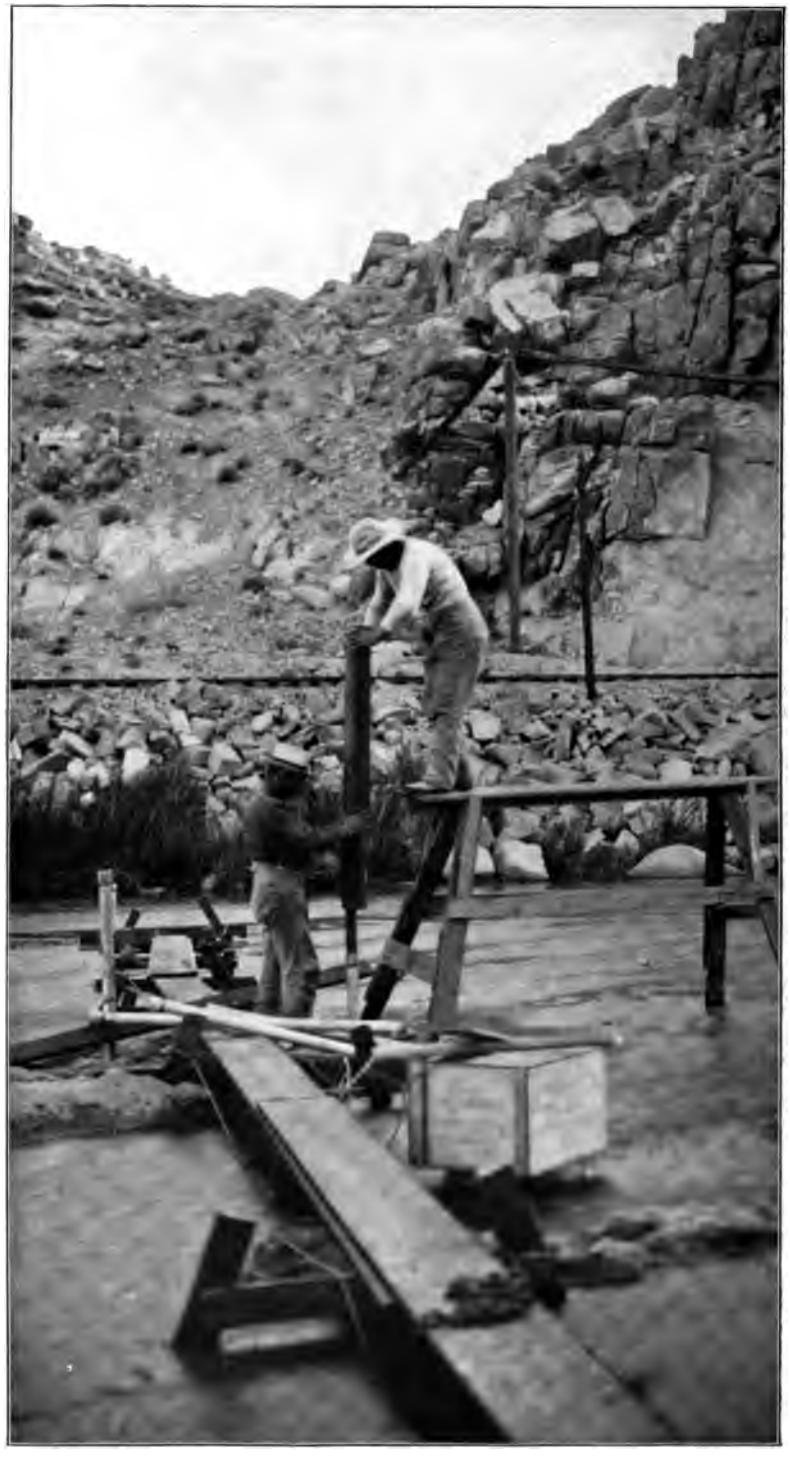


FIG. 37.—Diagram showing velocity of underflow at narrows of Mohave River, station E.

DRIVING WELL G AT UNDERFLOW STATION AT NARROWS OF MOHAVE RIVER.

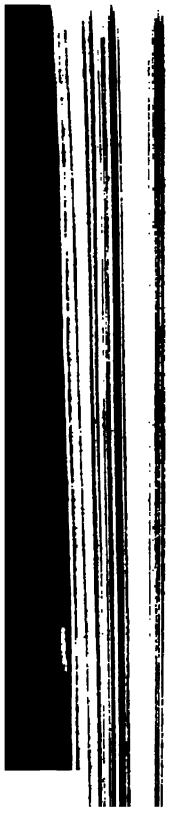
Showing shallow character of river at this place during dry season.





DRIVING TEST WELLS AT UNDERFLOW STATION AT NARROWS OF MOHAVE RIVER.

The wooden ram used weighed about 60 pounds.



own in fig. 35. In order to determine whether a variation in the ection was the cause of the failure to measure the underflow, some eliminary experiments were carried out at the position lettered E, st wells X and Y being driven 18 inches from the well F. After ese wells were put in place, the well E was salted. This test turned it to be unsatisfactory also, but a slight rise in the electric current well Y was noticed, which encouraged the belief that the direction

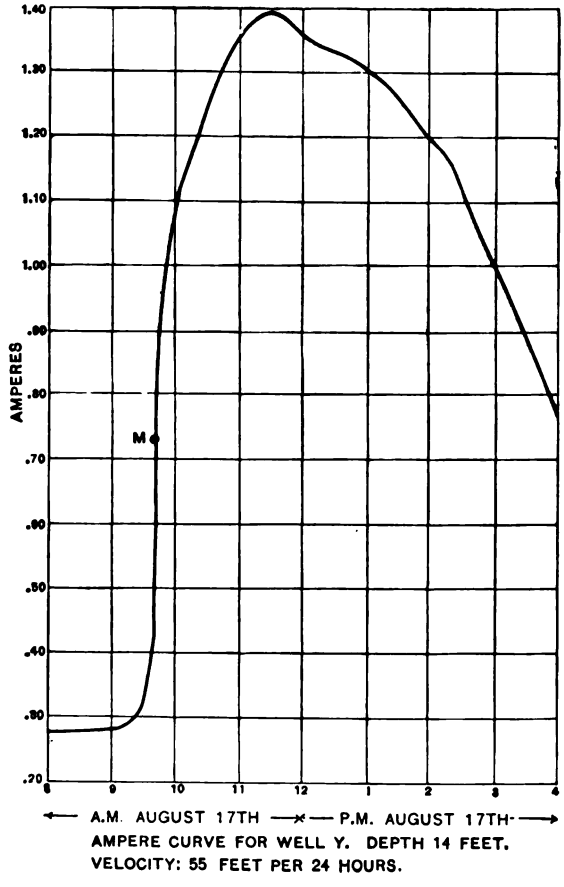


FIG. 38.—Diagram showing the velocity of underflow at narrows of Mohave River, station E.

of flow had been missed in the first test. It was surmised that the ground water might be moving so rapidly as not to give time for the electrolyte to spread sufficiently, and hence was able to pass between two downstream wells 18 inches apart. It was also possible that the direction of the flow was to the left of the new well Y. In order to provide for this contingency, the well X was pulled and redriven in the position indicated by the letter Z, 18 inches from Y.

If it were true that the motion of the ground water of the underflow might be so great that the electrolyte used in well E would not have time to spread sufficiently so as to be certain of coming in contact with one of two downstream wells 18 inches apart, it would be necessary to modify the method of salting E so as to cause, if possible, a wider path to be traversed by the electrolyte. This was finally accomplished by introducing into the well E, along with the dry sal ammoniac, about 10 per cent caustic soda, or common soda lye. This, of course, brought about a reaction between the two salts in solution, ammonia

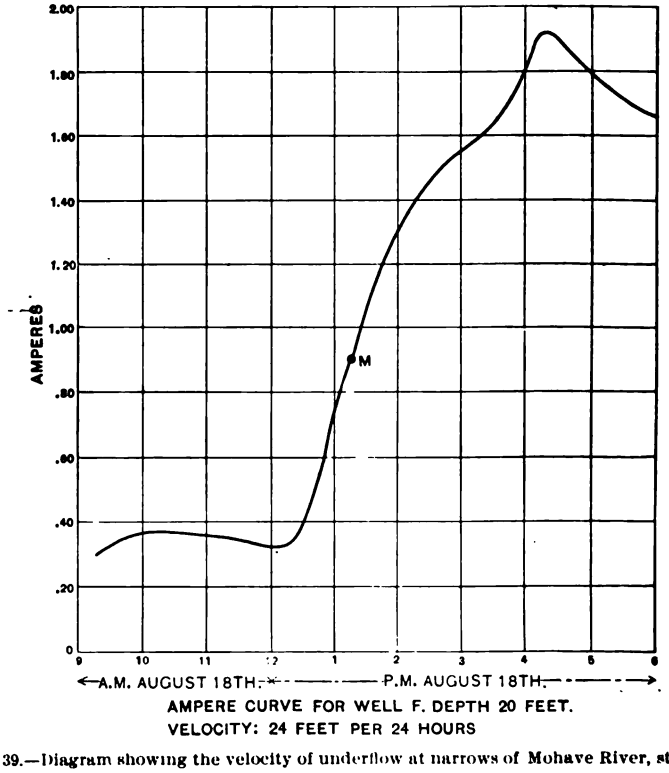
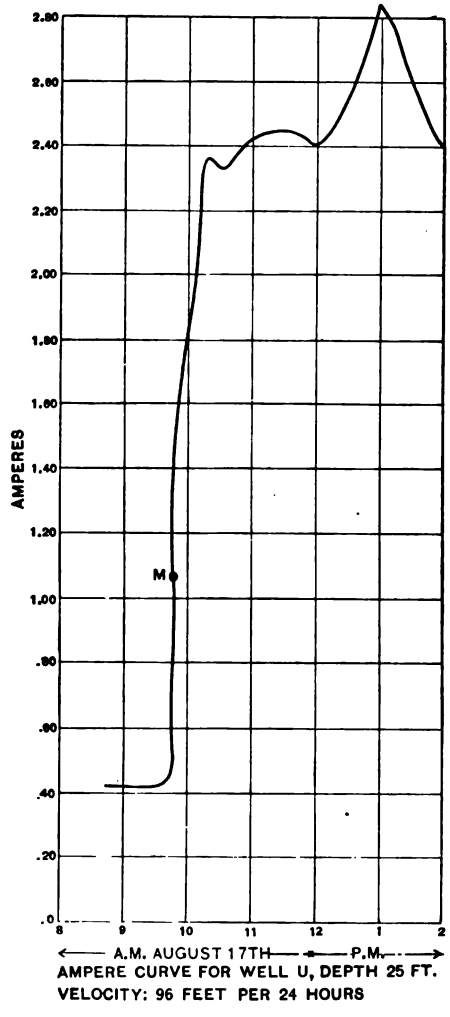


FIG. 39.—Diagram showing the velocity of underflow at narrows of Mohave River, station E.

gas being liberated. It was believed that the liberation of the gas would cause the mixed chemicals to spread more rapidly in the ground waters. This later seemed to be the case, for, carrying out the experiment in this way, it was found that the electrolyte reached well Y, where it showed itself very strongly and just grazed well F. The electrode curve for well Y is shown in fig. 40, which indicated a velocity of ground water of about 52.4 feet for twenty-four hours. This velocity was several times greater than any previously determined, which accounted for the difficulties encountered in interpreting the first failure and in getting the direction of flow. After this expe-

all of the upstream wells were salted with the same mixture of monia and caustic soda, and no further difficulties were experienced in getting the velocity and direction of flow. At the various ns, A, E, G, I, determinations of velocity were made at various s, as is shown by numbers inclosed in rectangular lines at approx points in the cross section, fig. 34. The pipe casing of well D



G. 40.—Diagram showing velocity of underflow at narrows of Mohave River, station G.

ound to be broken below the ground, and station C was on that nt not used.

depths below the surface not exceeding 25 or 30 feet the gravel gorge is completely silted with fine material deposited by the and is, of course, impervious. At stations E, G, and I, after

the well points were driven a few feet below the point at which the deepest measurements were made the points were completely embedded

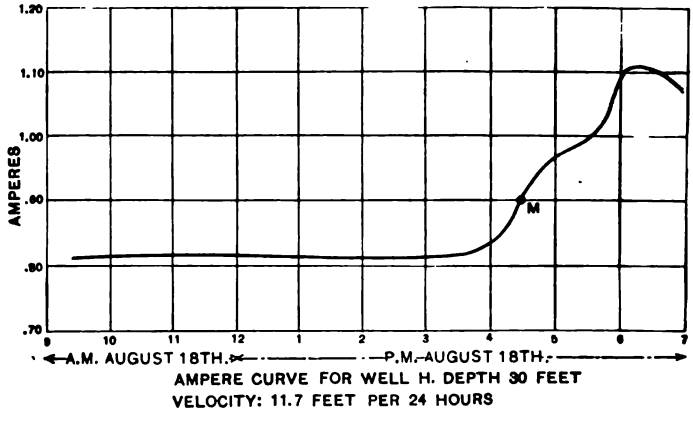


FIG. 41.—Diagram showing the velocity of underflow at the narrows of Mohave River, station G.

in the silted gravel and no water could be drawn from the wells with an ordinary pump. It was therefore very plain that the underflow of

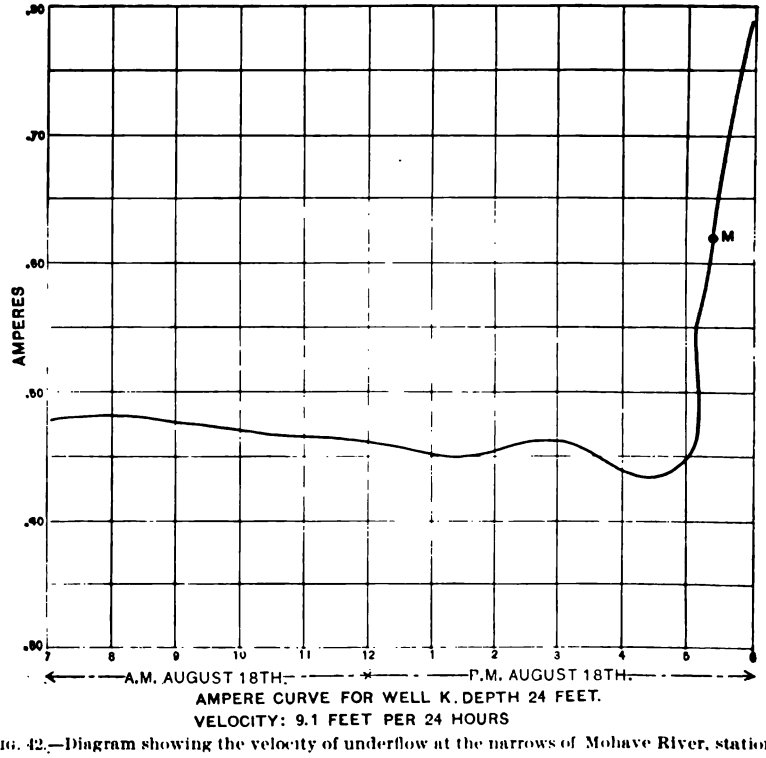


FIG. 42.—Diagram showing the velocity of underflow at the narrows of Mohave River, station I.

the gorge was confined to a depth not exceeding about 30 feet. Al of the velocities determined in the clear gravel of the gorge ran ver

gh, three of them exceeding a velocity of 50 feet for twenty-four urs. Taking Schuyler's figures for the area of the cross section of e gorge, 4,160 square feet, and assuming a mean velocity of ground ater in the entire section of 50 feet for twenty-four hours, and stimating the porosity of the gravel at 33⅓ per cent, the total under- ow in the gorge will be found to be less than 1 second-foot. This ust be understood to be a maximum estimate. The underflow robably does not exceed 300,000 gallons for twenty-four hours. he gradient of the water plane at and above the gorge is almost xactly 20 feet to the mile.

The reproductions of photographs shown herewith illustrate the nethod of driving the wells used and show the small footbridge and he test wells that were put in place during the investigation. The tent appearing at the left of the cut contained the instruments from which wires were led to the various test wells (Pl. IX).

QUALITY OF THE WATER.

The quality of the water in the surface stream and in the underflow of the Mohave River at the narrows was determined by tests with the Whitney electrolytic bridge, and the amount of chlorine in the water was determined by titration. The water is remarkable as a desert water for its unusual softness, being very much softer than the usual water found in southern California, as at Los Angeles and neighboring points. This softness is undoubtedly due to the insoluble character of the granitic deposit through which the water flows after leaving its mountain source. It should be remembered that both the surface water in the stream and the underground waters at the location of the narrows of the Mohave River has been flowing in a ground-water stream for 10 or 12 miles of its course. As all of this water reaches the narrows by passing underground for a considerable distance, the results of the few tests made, given herewith in Table X, are of considerable interest.

TABLE X.—*Quality of the water in the river and in test wells at the narrows of the Mohave River.*

[Total solids were determined with the Whitney electrolytic bridge.]

Well.	Date (August, 1902).	Depth in feet.	Temperature, ° F.	Resistance in ohms.	Chlorine, pts. per 100,000.	Total solids, pts. per 100,000.
A	10	8	72	1,125	.....	14
B	19	12	67	1,150	2.51	15
C	10	16	71	1,275	.....	12
F	10	7	72	1,150	1.77	13
G	10	20	70	1,300	.....	12
H	10	20	70	1,300	1.25	12
H	15	25	67	1,460	.....	11
J	10	14	72	1,250	1.77	12
Z	15	8	72	1,200	.....	12.5
River water	(a)	.....	67	1,200	2.01	13.5

a Aug. 10, 7 a. m.

It will be noticed that the temperature of the water from the deeper wells was somewhat lower than that near the surface, and the deeper water also appeared to be somewhat softer. The temperature of the ground waters remained nearly constant at the various depths, but the stream water showed very marked fluctuations in temperature, as would be expected in a shallow desert stream. The temperature of the stream water taken in the morning was always low. The temperature at 7 a. m. August 10 was 67° F., which was the usual morning temperature. During the day the temperature would rise, the extent of the rise depending upon the character of the day, temperatures as high as 82° being not uncommon. On cloudy days the temperature remained low. It will be noted from the table that the temperature of the surface stream was lower than the temperature of the upper underflow waters at night, and warmer than these waters during the daytime. This is already accounted for by the fact that the surface waters rise from the underflow but a mile or so above the narrows, the surface stream, of course, representing merely the surplus of underflow waters as the ground water approaches the narrows.

CHAPTER VI.

MEASUREMENTS OF THE RATE OF UNDERFLOW ON LONG ISLAND, NEW YORK.

CONDITIONS EXISTING AT THE STATIONS.

The following determinations of ground-water velocities were made along the south side of Long Island, between the villages of Freeport and Massapequa. These places are located about 6 miles apart, on the Montauk division of the Long Island Railroad, which between these points runs nearly east and west and is about 1 mile north of the edge of the extensive salt marshes which border the Atlantic Ocean.

Freeport is about 24 miles from Brooklyn Bridge, and Massapequa, 6 miles east of Freeport, is within 2 miles of the western line of Suffolk County.

Within the 6-mile stretch above mentioned the city of Brooklyn has five pumping stations, drawing water from extensive batteries of driven wells. The names of these stations, from the west, are: Agawam, Merrick, Matowa, Wantagh, and Massapequa. There is a brick conduit on the north side of the right of way of the Long Island Railroad, into which the water from the pumping station is discharged, carrying the water by gravity to a pumping station at Milburn, just west of Freeport, where an additional lift sends the water into the city of Brooklyn. The five driven-well plants above mentioned are used for auxiliary supply in the summer months, the period of use extending usually from July to December, but varying with the rainfall and other climatic conditions.

Within the 6 miles from Freeport to Massapequa the conduit crosses several small surface streams, four of which have been ponded and their waters gated into the conduit. These surface waters flow into the conduit the year round, the driven wells constituting the auxiliary supply.

The particular district under discussion was selected as the object of study because, in the first place, the region seemed typical of conditions on the southern side of the island, and, secondly, because the ground water was substantially in normal condition, owing to the fact that the driven-well plants had not been operated since the previous December. The purpose of this work was to determine the principal facts concerning the underground drainage of the island, so that a preliminary basis could be secured for an estimate of the amount of ground water available for municipal supply.

lay sheet, and to determine the order of magnitude of such a movement if it existed. Whenever there exists in any drainage area a body of ground water which does not escape into the beds of surface streams as seepage water, but continues a seaward course through the sands and gravels quite independent of the surface streams, this moving sheet of water is known as the "underflow." One of the problems was, therefore, to determine whether or not a true underflow existed in this part of Long Island, and to learn something of its magnitude if it was found to exist. Another problem was to discover, if practicable, if any part of the underground drainage existed below the bed of clay; in other words, it was sought to determine whether the underground drainage consisted only of a surface zone of flow, or whether a deeper zone, or possibly several deeper zones of flow, were also present.

In respect to the first problem above mentioned—the existence of an underflow—there can be no question that a true underflow of considerable importance exists within a depth below the surface of 40 to 50 feet. In practically all of the stations established a good movement was found to exist, having a strong southerly component, and surprisingly free, in many cases, from the influence of neighboring surface streams. The velocity near the surface, 16 to 24 feet below the water plane, ran as high as 5 to 12 feet per day. At greater depths of 30 and 42 feet, respectively, the velocities were in each case about 15 inches per day. At station 9 the sand was so fine at a depth of 45 feet that it could not be prevented from running into the bottom of the well above the top of the well strainer so that the wells could not be used.

The existence of a deep zone of flow was also established. At station 15 clay was encountered at a depth of about 44 feet. These wells were driven to a depth of about 62 feet, when an artesian head of about 30 inches developed. A measurement was then made, the screens on the wells being just below the impervious layer. A velocity of 6 feet a day was found to exist in a direction about 10° west of south. The rate of flow at the same point just above the clay was only 18 inches a day, so that a true "deep zone of flow" undoubtedly exists at this point. This result, although very important, was not surprising, as it had already been well established by the work of Mr. A. C. Veatch and others, of the United States Geological Survey, that the clay layer, formerly supposed to be of wide expanse and quite unbroken, is, as a matter of fact, absent over considerable areas of the island, so that no reason exists why a part of the underground drainage should not exist below this impervious bed. It is strongly urged that further measurements below the clay be made. Measurements made some distance to the east of the present work, say, in Suffolk County, would be of especial value in indicating the areal extent of this deep zone of flow.

The surface zone of flow of the underground waters is probably divided into a number of drainage areas, although it is exceedingly doubtful if the underground drainage basins coincide very closely with the drainage areas of the surface streams. In general, the velocities seemed to increase from west to east, the lowest velocities, however, corresponding to a middle area, where the yellow gravels contained a quantity of fine, clay-like silt. The Wantagh area seemed to have the largest underflow. It would be exceedingly interesting to have series of measurements extending eastward into Suffolk County. By increasing somewhat the number of stations in

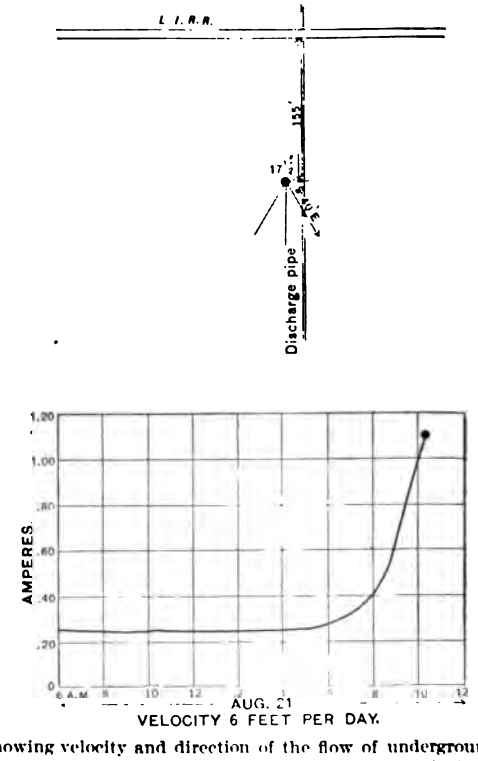


FIG. 43.—Diagram showing velocity and direction of the flow of underground water at Wantagh pumping station (station 2 X). Velocity, 6 feet a day, S. 40° E. This velocity was determined while pumps were drawing water from the wells of the driven well plant at a rate of 4,366,000 gallons per twenty-four hours. No velocity detected when not pumping.

the area already covered and comparing with results from drainage areas in Suffolk County, a comparative study of underground drainage systems would result which ought to have much value in planning sources of supply for Brooklyn.

The details of the measurements are given in the reports on individual stations contained in Table XI. The locations of the stations are shown in fig 57, and the curves of electrical current for the various stations are given in figs. 5 and 43 to 56.

TABLE XI.—*Underflow measurements on Long Island.*

Number of station.	Velocity of ground water; feet a day.	Direction.	Date, 1903.	Depth of wells in feet.	Kind of point.	No. of text figure.
1	5.5	S. 10° E	June 21	22	Perforated pipe.	5
2	2	.....	June 24	22	Do.	.....
2 X	6	S. 40° E	Aug. 21	22	Do.	43
3	2	.....	June 26	22	Do.	.....
4	2	.....	June 27	22	Do.	.....
5	6.4	S. 8° W	June 29	22	Common point.	44
5 X	5.4	S. 8° W	July 3, 4	22	Do.	
5 Y	8.0	S. 22° E	Aug. 19	22	Do.	
6	5.0	S. 8° W	July 1, 2	34	Do.	45
7	2.6	S	July 5, 6	20	Do.	46
8	0.0	S	July 9, 10, 11	21.6	Open-end point.	.....
8	3.1	N. 34° W	July 14, 15, 16, 17.	21.6	Do.	47
10	2.6	S. 37° E	July 17, 18, 19, 20.	28	Common point.	48
11	0.0	.....	July 27–Aug. 8.	22	Do.	.....
12	1.07	S. 3° E	July 27–Aug. 1.	27	Open-end point.	49
13	96.	S	Aug. 3, 4	16	Common point.	53
13	6.9	S	Aug. 3, 4	16	Do.	
14	9.3	S	Aug. 5, 6	17	Do.	50
15	1.53	S	Aug. 6, 7, 8, 9, 10.	42	Open-end point.	51
15 X	6.00	S. 15° W	Aug. 17, 18, 19.	62.5	Do.	52
16	0.	S. 30° E	Aug. 10, 11.	16	Common point.	.....
16 X	77	S. 60° E	Aug. 13, 14.	16	Do.	54
16 X	11.6	S. 60° E	Aug. 13, 14.	16	Do.	
17	10.6	S. 30° W	Aug. 12, 13.	20	Do.	55
18	1	S	Aug. 15–21.	62	Open-end point.	.....
21	21.3	S. 50° E	Aug. 18, 19.	16.5	Common point.	56
22	5.6(?)	S. 30° E	Aug. 20, 21.	16	Do.	.....

INFLUENCE OF THE RAINFALL UPON THE RATE OF MOTION OF GROUND WATERS.

An excellent opportunity was presented at one of the stations for noting the influence of a heavy rain upon the velocity of ground waters.

At station 5, Agawam pumping station (see figs. 58 and 44), the upstream well, A, was salted at 9.45 a. m., June 29, 1903. Between

9 a. m. and 1 p. m. nearly 3 inches of rain fell, so that the heavy precipitation coincided with the early part of the ground-water measurements. The velocity found was 6.4 feet a day. On July 3 the experiment was repeated, there being no rain in the intervening time. The velocity found in the second trial was 5.3 feet a day. The change in velocity was undoubtedly due to the enormous rainfall during the first experiment. Part of the high velocity during the rain storm may be attributed to the low barometer accompanying the storm, but part

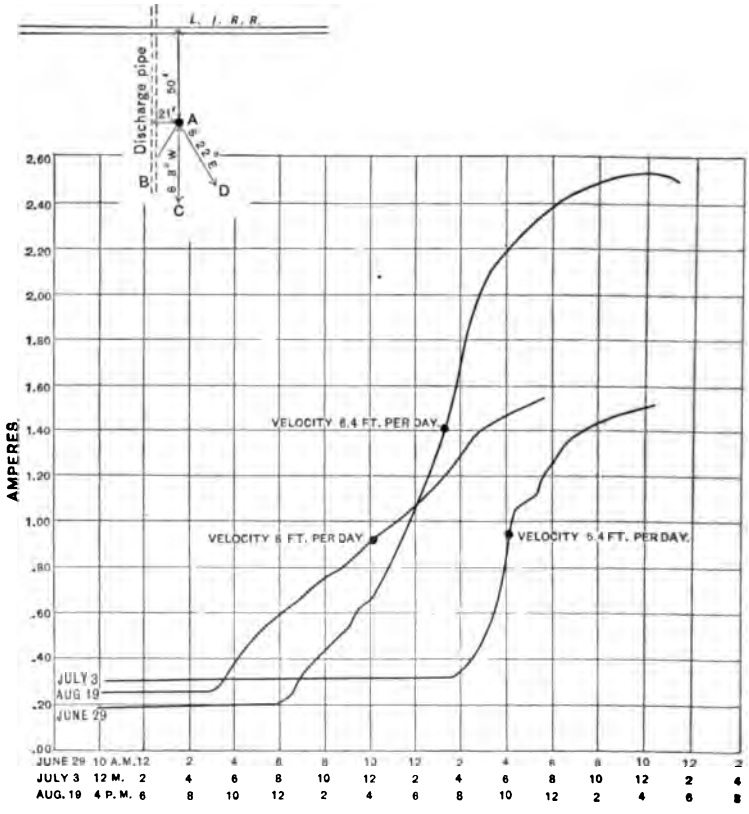


FIG. 44.—Diagram showing three determinations of velocity and direction of flow of underground water at Agawam pumping station (station 5). Normal velocity of ground water, 5.4 feet a day, S. 8° W. Velocity during heavy rain, 6.4 feet a day, S. 22° E. Velocity while pumping from the lines of driven wells, 8 feet a day, S. 22° E.

of it should be assigned to the increased head of ground-water pressure and to increased load carried by the soil, caused by the heavy rainfall upon the receiving area.

As is shown in another place[a] ground waters move very much as electricity is conducted in a good conductor, the most striking quality being an almost complete absence of true inertia in ground-water motions. The motion of a mass of ground water, even for the highest

[a] Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1899, p. 331.

locities, is so slow that the resistance to an accelerating force represented by the inertia of the ground water is almost nothing when mpared with the component of the retarding force due to the pillary resistance in the small pores of the sand or gravel. Actual mputation will show that in a uniform sand of diameter of grain of ne-half millimeter, the ground water will reach within 1 per cent of s final maximum velocity due to a sudden application of pressure, r head, in approximately thirty seconds of time. This surprising esult of the theory of ground-water motions receives a very striking erification in the increase in velocity noted during the rainstorm as escribed above.

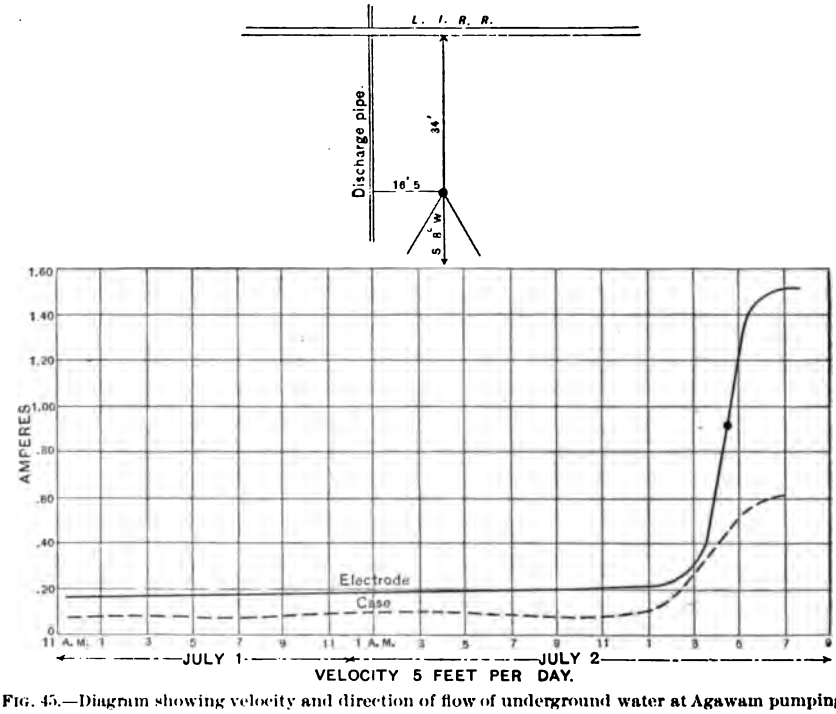


FIG. 45.—Diagram showing velocity and direction of flow of underground water at Agawam pumping station (station 6). This station is located near station 5, but wells were 12 feet deeper.

These results have important bearings on our knowledge of ground-water phenomena in the neighborhood of a well. They indicate that the velocity of the ground waters in the neighborhood of a well reaches a maximum value soon after pumping is commenced. The gradual formation of the cone of depression near the well shows that there must be a progressive augmentation of the initial velocity of the ground waters toward the well. Nevertheless, the rate of depression of the water table is so slow that the ground-water motion established soon after the pumping has begun is substantially the same as its value after prolonged pumping. These remarks have their most

important bearing upon the phenomena of the mutual interference of wells. The interference of one well with the supply of a neighboring well is thus seen to come into existence almost instantaneously and need not wait for the establishment of a cone of depression of large area. The phenomenon of the cone of depression has much to do with the permanent supply of the well, but has slight bearing upon the proper spacing of the wells or the percentage of interference of one well with another.

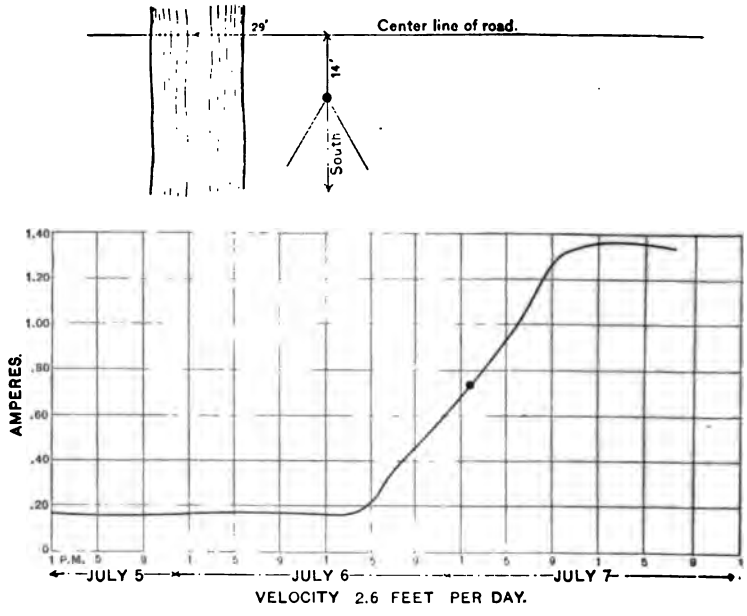


FIG. 16.—Diagram showing velocity and direction of flow of underground water at East Meadow Brook and Babylon Road (station 7). This station is a short distance above Agawam Pond, and the velocity is reduced by the flat water plane due to the presence of the pond. Velocity, 2.6 feet a day, south.

SEEPAGE WATERS FROM PONDS AND RESERVOIRS.

The work on Long Island afforded some unusually good opportunities of determining the rate of seepage below the impounding dams of some of the storage ponds which the Brooklyn Water Works has established north of the conduit line referred to in the opening pages of this chapter. The batteries of driven wells, which have been placed a few hundred feet south of nearly all of these ponds, were not used during the summer of 1903, as the heavy rains furnished a sufficient quantity of surface water, and the auxiliary supply from the wells was not drawn upon, as usual, during July and August. Station 5 is below the Agawam Pond and somewhat within the line of seepage from the pond, as can be seen by consulting fig. 58. The normal velocity of

round water at this station is 5.3 feet a day. At station 7, just north of the pond, the velocity was 2.6 feet a day. It seems clear that the natural velocity at these points, if the influence of the dam and pond were removed, would be about 4 feet a day. The velocity at station 6, located but a few feet from station 5, was 5 feet a day at a depth of 34 feet, as compared with 5.3 feet a day at a depth of 22 feet. The dam has the effect of making the water table nearly level in the immediate neighborhood of the pond, and also of greatly augmenting the slope of the water table for a short distance below the pond. The lower velocity above the pond and the higher velocity below the pond correspond

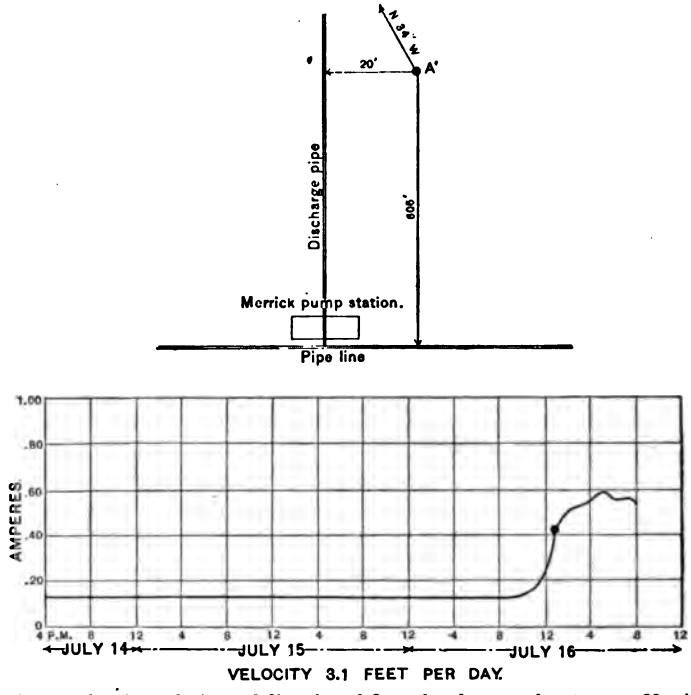


FIG. 47.—Diagram showing velocity and direction of flow of underground water near Merrick pumping station (station 8). The ground water at this point slopes in a northerly direction toward the brick conduit north of the Long Island Railroad. The velocity found was 3.1 feet a day, N. 34° W. The northerly flow at this point is undoubtedly due to seepage into the conduit.

with these facts. When there was no flow over the waste weir of the dam, the flow of the small stream which rises below the dam was measured at the bridge marked A in fig. 58. On July 10 this flow was 1.2 second-feet, practically all of which represented seepage water from the reservoir.

A flow of 1.2 second-feet or 103,000 cubic feet a day represents an amount of water flowing through a bed of sand 30 feet deep and 1,000 feet wide, at a velocity of 1 foot a day, the porosity of the

sand supposedly being equal to one-third. The normal velocity of the ground water is augmented, as shown by the measurement quoted above, by somewhat more than 1 foot a day. The width of the lower end of this pond, or the length of the earthen dam, is about 1,400 feet, so, basing the estimate on this minimum length and on a minimum depth of 30 feet, an augmented velocity of 1 foot a day would give a minimum estimate of the seepage from the dam of 1.6 second-feet. Since 1.2 second-feet are known to actually come to the surface to feed the stream below the dam, it is evident that this estimate of seepage is a minimum. It seems evident that a considerable volume of

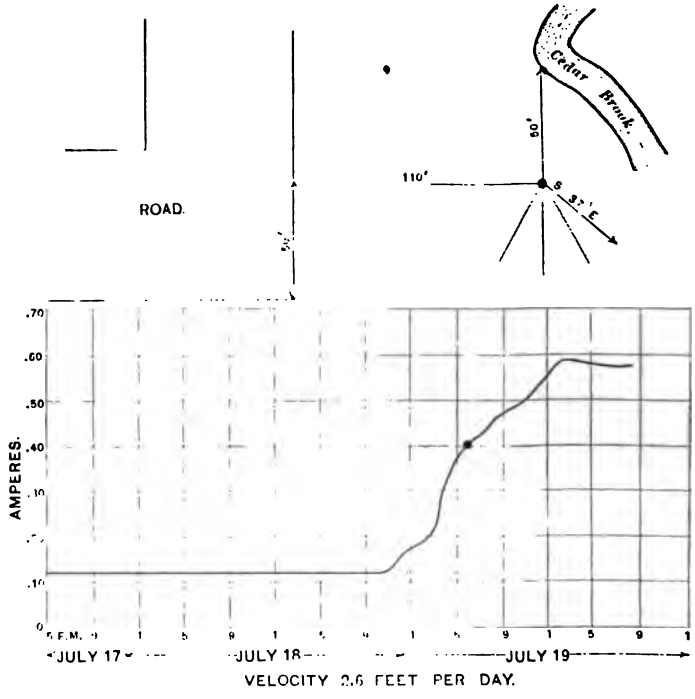


FIG. 18.—Diagram showing velocity and direction of flow of underground water at Cedar Brook station 10c. This station is above Cedar Brook Pond. The velocity is 2.6 feet a day, S. 37° E.

seepage water could be recovered by extending the line of driven wells of the Agawam pumping station to the east of the present terminus, a distance of 600 or 700 feet, without serious lowering of the water plane.

A test well was driven in the lower south end of Agawam Pond to a depth of 10 feet to determine the pressure gradient of ground water beneath the surface of the pond. The water in this test well stood about 1 foot lower than the water in the pond itself, showing a slope of the water plane or a hydraulic gradient of 7 feet to a mile.

The gradient of the water plane below the dam—that is, between the m and station 5—was 17 feet to the mile, so that the velocities to be mpared are:

Station 7 above pond; gradient, 7 feet per mile; velocity, 2.6 feet a day.
Station 5 below pond; gradient, 17 feet per mile; velocity, 5 feet a day.

These results check very favorably, especially when it be considered at the gradient above or north of station 7 was probably 10 or 12 eet per mile, which would make the effective gradient at this station omewhat greater than 7 feet per mile.

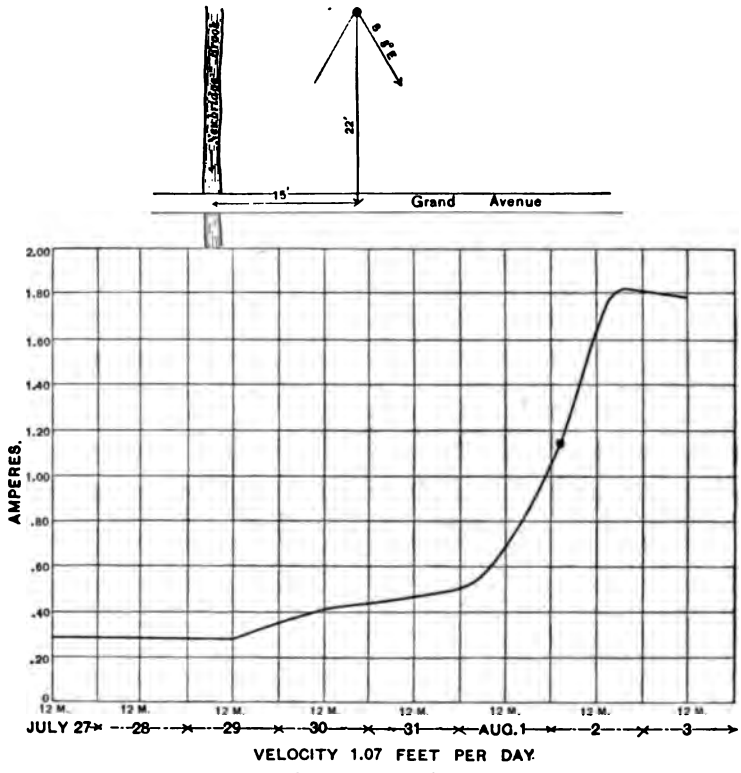


FIG. 49.—Diagram showing velocity and direction of the flow of underground water at Grand Avenue and Newbridge Brook (station 12). Velocity, 1.07 feet a day, S. 3° E. This is the lowest velocity determined on Long Island.

Very striking results were obtained below the dam at the Wantagh Pond, where measurements were undertaken to determine the rate of seepage. The dam of Wantagh Pond runs parallel to the right of way of the Long Island Railroad, about 75 feet north of the road, and has an extreme length of 500 or 600 feet. About 150 feet south of the railroad, downstream from the reservoir, the city of Brooklyn began in 1903 the construction of an infiltration gallery, consisting of a line of 36-inch double-strength tile, laid at a depth of 16 feet below the

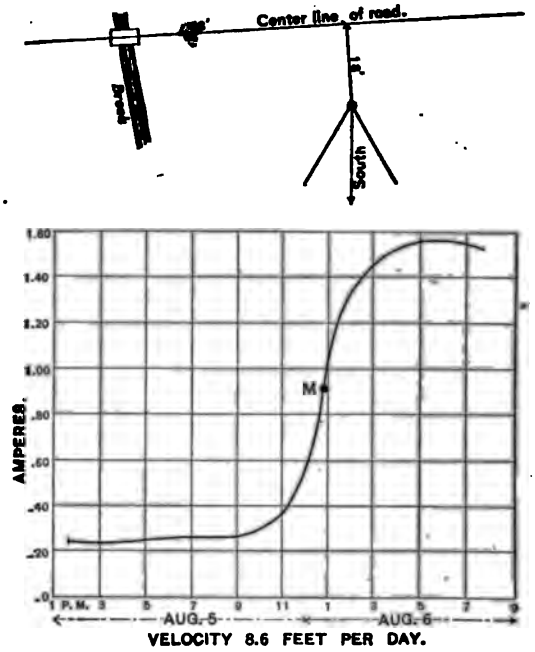


FIG. 50.—Diagram showing velocity and direction of flow of underground water at Bellevue roa (station 14). Velocity, 8.6 feet a day, south.

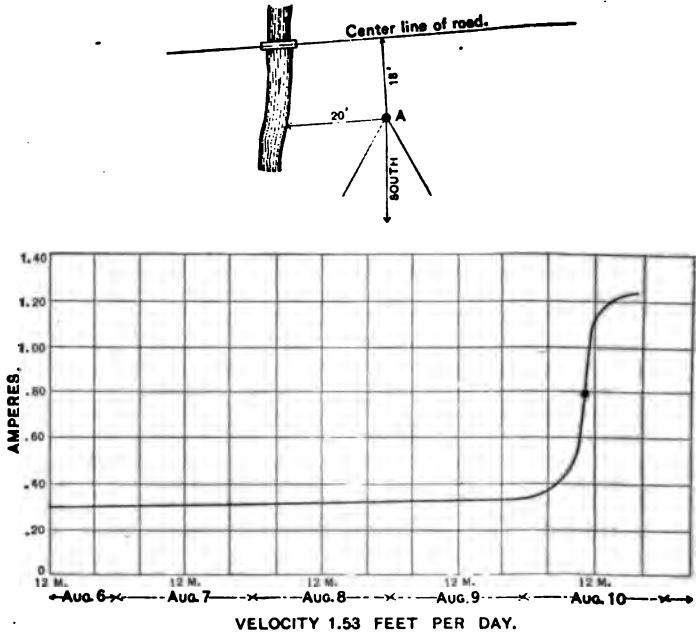


FIG. 51.—Diagram showing velocity and direction of the flow of underground water at Bellevu road (station 15). Velocity, 1.53 feet a day, south.

ter plane. It is proposed to extend this gallery for a mile east and st from the Wantagh pumping station. Stations 13, 16, and 17 were ablished for the purpose of measuring the normal ground-water locities at the depth (16 feet) of the proposed gallery. Two of these ations are immediately south of the pond and in the apparent direct ie of seepage, while station 17 is located slightly east of the edge of ie pond and, as seems evident from fig. 59, just on the edge of the ain influence of seepage from the ponds. The seepage velocities at ations 13 and 16 turned out to be enormous, the velocity at station 3 being 96 feet a day, south, while at station 16 the velocity was 77 eet a day, the direction being about 30° east of south, the deflection eing toward the neighboring stream, as shown in fig. 59. These

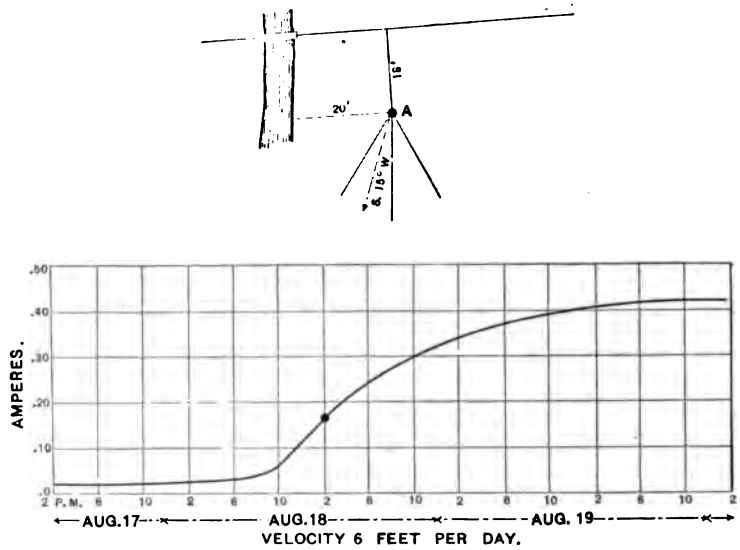
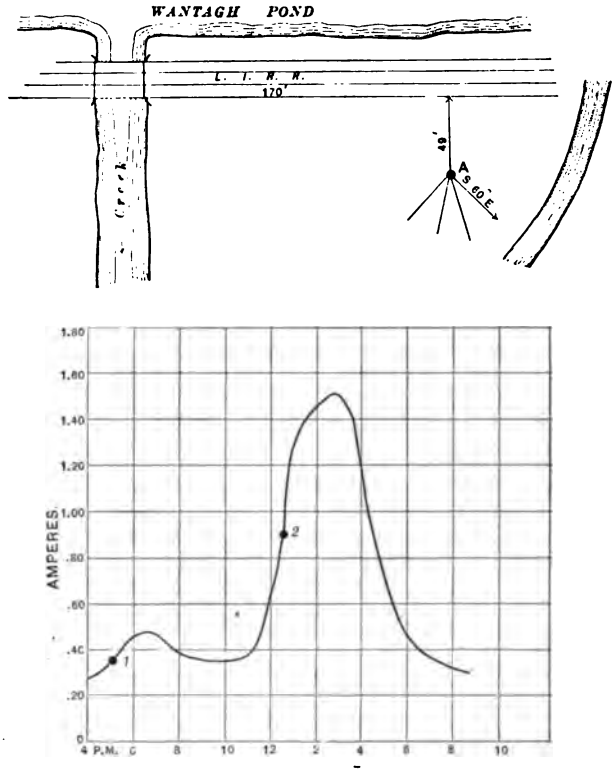


FIG. 52.—Diagram showing velocity and direction of the flow of underground water at Bellevue road (station 15 X). Velocity, 6 feet a day, S. 15° W. This station is the same as station 15, but measurement of velocity was made below a stratum of clay or bog material at a depth of 62.5 feet, 20 feet deeper than the measurement shown in fig. 51.

velocities are the highest the writer has determined. They may be regarded as record-making rates for the horizontal motion of ground waters. Both measurements were made with the recording instruments, and by consulting the curves in figs. 53 and 54 it will be noted that each curve has two maximum points, which must correspond to the velocities in two distinct layers of gravel. The secondary velocity for station 13 was 7.4 feet a day and for station 16, 11.3 feet a day. A very striking verification of the fact that the high movements here found were due to the escape of water from the pond will be noted when the temperatures of the waters in the wells of these stations are compared with the temperatures of the water in the pond and the water

ater has not time to be reduced to the normal temperature of the ound.

The velocity at station 17 was 10.6 feet a day in a direction 30° west south. The temperature of the water was 61.5° F. The ground ater at this point is probably not entirely free from the seepage ater from the pond. The direction of flow, the velocity, and the mperature of the water all indicate, however, that a considerable



VELOCITY: (1) 77 FEET PER DAY; (2) 11.6 FEET PER DAY.

FIG. 54.—Diagram showing velocity and direction of flow of underground water at Wantagh Pond (station 16 X). This station is near station 13, and the curve shows two distinct velocities in different strata. Velocities, 77 and 11.6 feet a day, S. 60° E. The stream just east of the station seems to deflect the direction of flow toward itself.

part of the water is the natural underflow, which at this point is diverted toward the lowland occupied by the streams below the pond.

There can be no doubt but that the proposed infiltration gallery will intercept a large amount of seepage water from the pond, which at the present time runs entirely to waste. The amount of seepage in the first 16 feet in depth is probably somewhat less than 3 second-feet per 1,000 feet of length of cross section, or about 2,000,000 gallons per twenty-four hours.

At station 21, located just above Wantagh Pond, the velocity at a depth of 17 feet was 21.3 feet a day in a direction 60° east of south. This station is near the west bank of the main brook that feeds the pond, and the greater portion of the ground-water at this point percolates into the bed of the stream. The true underflow at this point can be found by taking the southerly component of this velocity, which gives 10.6 feet a day. The temperature of the ground water at this point was 58° F.

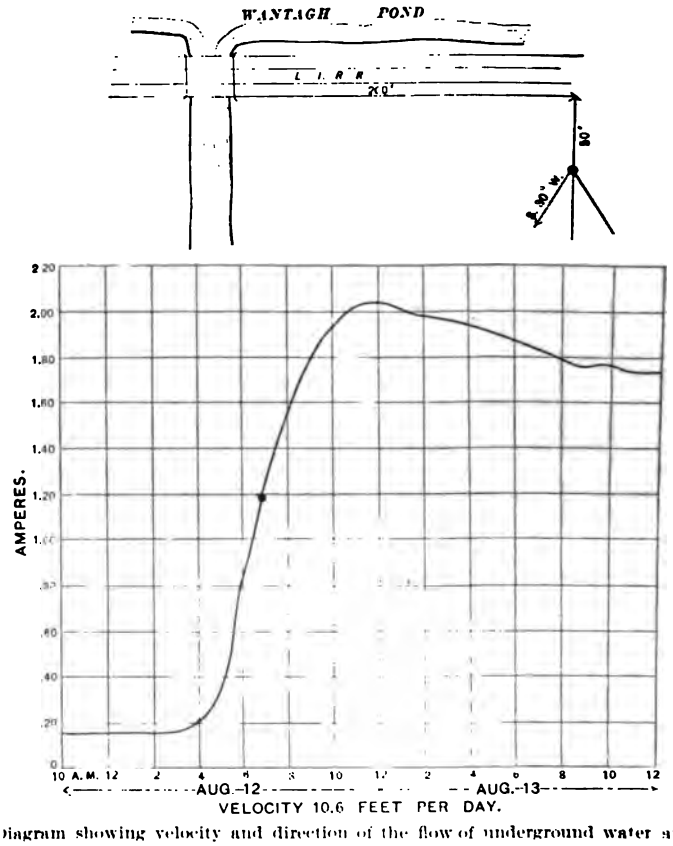


FIG. 55.—Diagram showing velocity and direction of the flow of underground water at Wantagh Pond (station 17). Velocity, 10.6 feet a day, S. 30° W.

The increase of underflow rate at the Wantagh Pond from 10.6 feet a day above the pond to 96 and 77 feet a day below the pond, as compared with velocities above and below Agawam Pond, 2.6 and 5.3 feet a day, respectively, is easily understood when the material constituting the bottom of the ponds is inspected. The material at Agawam is good, the soil being fine and compact, while at Wantagh the bottom of the pond is very sandy, in some places having a closer resemblance to a filter bed than to a puddled floor.

INFLUENCE OF PUMPING UPON THE RATE OF MOTION OF GROUND WATERS NEAR SOME OF THE BROOKLYN DRIVEN-WELL STATIONS.

Through the courtesy of Mr. I. de Verona an excellent opportunity was furnished the writer of making some observations on the influence of pumping upon the normal rate of motion of ground waters in the neighborhood of some of the Brooklyn driven-well stations. For this special purpose the pumping stations at Agawam and Wantagh, which had been idle since December, 1902, were started up for two days each in August, 1903. Agawam was operated continuously from 7 a. m.,

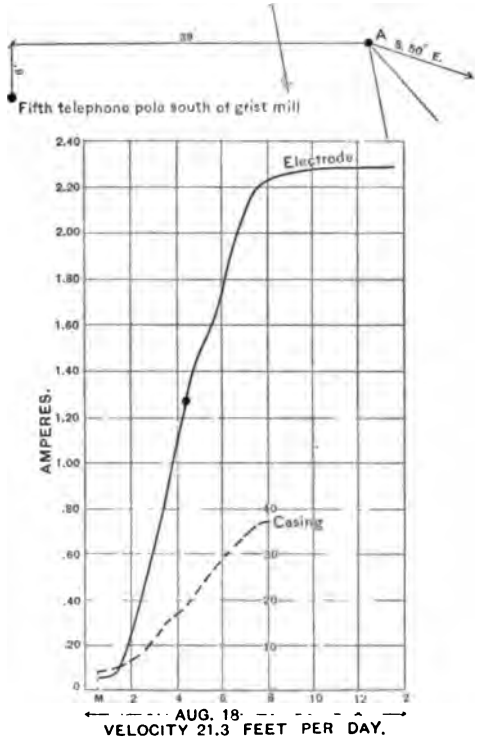


FIG. 56.—Diagram showing velocity and direction of the flow of underground water (station 21). Velocity, 21.3 feet a day, S. 50° E.

August 19, to 7 a. m., August 20. At the Agawam station observations were made at station 5 by means of the recording instrument. Well A was charged at 4 p. m., August 19, or after nine hours of continuous pumping. After this length of time it was expected that the maximum rate of flow of ground water would be established, although, of course, the cone of depression near the wells would still be changing quite rapidly.

Station 5 is 30 feet north of the intersection of the chief suction mains communicating with the line of driven wells and 12 feet east of

the central discharge main (see fig. 58). The depth of the test wells is 22 feet, while the depth of the 30 wells of the Agawam station system varies from 30 to 105 feet.

The rate of pumping during the forty-eight-hour test was very uniform, at an average rate of 2,250,000 gallons per twenty-four hours. The vacuum at the pump was maintained at 24 inches, while that at the first well east of the engine-house was 23.2 inches. The charge of the centrifugal pump was dropped from 4 p. m. to 4.40 p. m.,

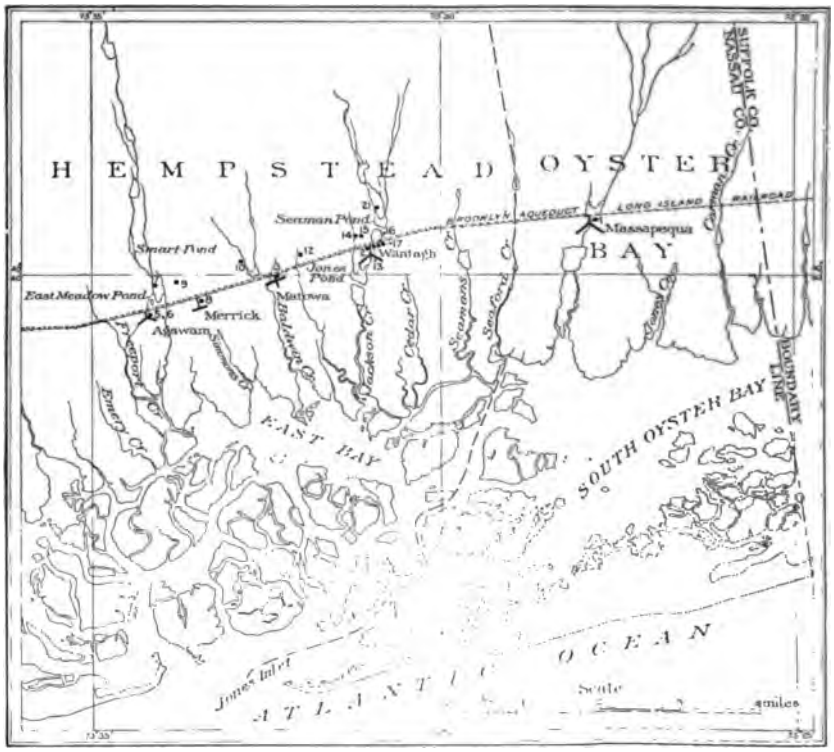


FIG. 57.—Map showing location of overflow stations, at which determinations of the rate of flow of underground water were made on Long Island. The Brooklyn driven-well pumping stations are located on the south side of the railroad and are named, from east to west, Massapequa, Wantagh, Matowa, Merrick, and Agawam.

August 19, during which time the vacuum fell to 7 inches. This was the only interruption during the test.

The velocity determined at station 5 during the test was 8 feet a day in a direction S. 22° E. The normal velocity at this station is 5.4 feet a day, S. 8° W., so that the influence of the pumping was to increase the velocity by 2.6 feet a day, or an increase of about 50 per cent (fig. 44). The actual velocity found and the percentage of increase are both very moderate, and indicate that the pumping station is not making an unreasonable draft upon the ground-water supply at this point.

The 30 wells of the Agawam supply station have screens each 10 feet long, or, altogether about 730 square feet of screen. The maximum velocity of the ground water as it enters these screens must be 1,230 feet a day, since the actual pumpage was 2,250,000 gallons or 300,000 cubic feet per twenty-four hours. The mean velocity in the area (10 by 1,500 feet cross section) immediately drawn upon by the wells was about 30 feet a day. The reduction of this rate to 2.7 feet a day represents a ratio of reduction of 11, which could be taken care of by a depth of 110 feet in the water-bearing gravels, without going outside of the 1,500 foot east and west line of the driven wells.

To put this in another way: the daily pumpage of 300,000 cubic feet of water could be supplied by the normal rate of motion of the ground

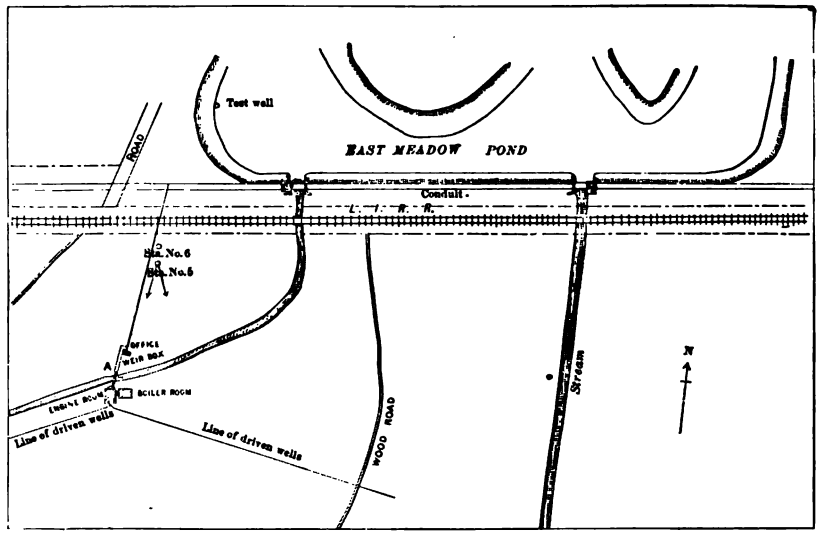


FIG. 58.—Map showing location of stations 5 and 6 with reference to Agawam pumping station and East Meadow Brook Pond. The surface stream was gaged at the bridge marked A. The normal direction of ground-water motion at station 5 was S. 8° W. During a heavy rain, and also when the pumps were drawing water from the lines of driven wells, the direction of flow changed to S. 22° E., as shown by the arrows drawn from station 5.

water at this point (5.4 feet a day) through a cross section of 510,000 square feet, or, say, 100 feet deep by 1 mile wide. To supply this amount of water, if removed from the ground on each of the three hundred and sixty-five days in a year would utilize 1 foot of rainfall on 12 square miles of catchment area. These amounts are not excessive. The rate of removal of ground water at the Agawam station must therefore be regarded as exceedingly moderate.

The observations at Wantagh pumping station were made on August 21 and 22. The pumping at this station began at 7 a. m., August 21, and continued forty-eight hours at the uniform rate of 4,366,000 gallons per twenty-four hours. The water at this station is drawn

from 48 driven wells, arranged on three lines of suction mains as shown in fig. 59. The east and west expanse of the two chief lines of wells is about 1,500 feet. The wells of this station are of two different types, shallow wells of depth of about 24 feet and deeper wells, extending below an impervious bed to depths of from 60 to 112 feet. These latter wells have an artesian head of 3 or 4 feet, and when the pumping plant is idle the water from the deep wells flows into the suction main and into the shallow wells, whence the water escapes into the sands and gravels of the upper zone of flow. An attempt was made on June 24 to measure the rate of motion of the ground water at station 2, situated 17 feet west of the chief discharge pipe and 300 feet north of the intersection of the main suction pipes from the driven wells, as shown in fig. 59. The attempted measurement was a failure, it not being

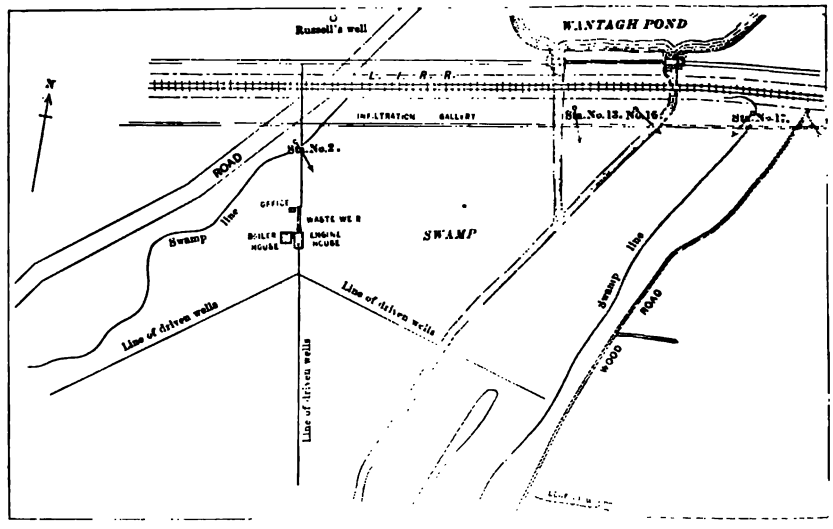


FIG. 59.—Map showing location of stations 2, 13, 16, and 17 near Wantagh pumping station and Wantagh Pond. The arrows indicate the direction of flow of ground water. The flow at station 2 was observed while pumps were drawing water from the three lines of driven wells.

known at that time that the discharge from the numerous artesian wells was entering the surface layers of gravels and hence interfering with the normal flow in these gravels. The ground water at station 2 was, on account of this situation, either entirely stationary or moving slightly toward the north. On August 21 well A of station 2 was charged at 6 p. m., or after eleven hours of continuous pumping from the driven wells. The velocity of the ground waters observed was at the rate of 6 feet a day in a direction 40° east of south. As this station is distant only 300 feet from the lines of driven wells, it is evident that the withdrawal of 4,366,000 gallons, or 582,000 cubic feet, per twenty-four hours has not an excessive influence on the normal rate of motion of the ground waters. The results at Wantagh compare very well with

he results at Agawam, and indicate that the driven-well plants have not exhausted the possibilities of ground-water developments.

CONCLUSION.

The very evident conclusion from observations on Long Island is that large amounts of ground water can still be obtained along the south shore of the island, especially if deep wells of large diameter can be successfully bored. The writer has already called attention to the possibility of constructing 12-inch wells of the California or "stovepipe" type in the unconsolidated material which extends from the surface to considerable depths on Long Island. Such wells, several hundred feet in depth, with perforations opposite the best water-bearing material, would utilize a large part of the underflow which now escapes to the sea. The practicability and success of such wells in this locality seems very probable, but the only way to arrive at an entirely satisfactory conclusion is to actually construct a test well.

CHAPTER VII.

THE SPECIFIC CAPACITY OF WELLS.

GENERAL PRINCIPLES.

The amount of water discharged or obtained from a tubular well is a quantity which is as rigidly dependent upon certain definite and measurable factors as the total horsepower of a steam engine is dependent upon the elements in its design and the pressure of steam furnished to the engine. Very few persons realize, however, the closeness and intimacy of the dependence of the yield of a well upon the various causes represented by the character of the water-bearing material in which it is constructed and the size and shape of the well itself. In fact, the available published data containing the results of actual tests of the capacity of wells are usually incomplete in some important particular, so that no laws or general principles are discernible even where they exist. With every well, no matter what its size or method of construction, there can be associated a perfectly definite quantity which expresses the capacity of that well to furnish water. In order to add definiteness to well construction and well data, such a quantity should be applied to every well whose capacity is measured. It can conveniently be designated by the term "specific capacity." By "specific capacity" of a well is meant the amount of water furnished under a standard unit head, or the amount of water furnished under unit lowering of the surface of the water in the well by pumping. This number can be made definite by agreeing upon the unit of measure of quantity of water and on the unit in which the head is to be measured. If the unit of yield be the "second-foot," or cubic foot of water per second of time, and if the hydraulic head be measured in feet of water, then the specific capacity of any well is found by dividing the number of second-feet by the hydraulic head. For example, if an artesian well flows 2 second-feet, and if the static head in the well when the water is not permitted to flow is equivalent to a head of 20 feet of water, then the specific capacity of the well is 2 divided by 20, or 0.1 second-foot. We describe the specific capacity by saying that the specific capacity of the well is 0.1 second-foot. Likewise, if we desire to speak of the specific capacity of a common tubular well which is not artesian in character, we can proceed in a similar way. For example, if the well yields 2 second-feet when the water in the well is lowered 20

feet below its normal position, the specific capacity is found by dividing 2 second-feet by 20, giving a specific capacity of 0.1 second-foot.

For the purpose of expressing the capacity of wells, the second-foot will be found to be a large unit of capacity, so that it will often be convenient to express the yield in gallons per minute, rather than in second-feet. One second-foot is equivalent to about 450 gallons per minute, so that the specific capacity of the wells above given might be stated as "45 gallons per minute." Another convenient unit of measure for the capacity of the well is the miner's inch, the California miner's inch being one-fiftieth of a second-foot, and hence of a very convenient size for the measurement of well capacity. However, the different values of the miner's inch prevalent in various sections of the country make this unit of measure undesirable for general use.

The importance of accurate knowledge of the specific capacity of the wells of a locality can not be overestimated. To the owner of a well it is very important that he know whether or not his well is better or poorer than neighboring wells, and whether the difference is due to a diversity in pumping machinery or to a difference in the well itself. To one who contemplates the construction of a well it is of the first importance that he know how much water he may expect to obtain, and in what manner it can best be obtained. In spite of striking examples of irregularity, it is usually true that the same water-bearing material is very uniform in a given locality, and by properly designing a well one should be able to estimate in advance of construction the capacity of a well with a very small per cent of error. However, tests on existing wells and all data concerning them will have to be obtained and recorded with much greater accuracy and completeness than heretofore if this desirable result is to be realized.

It does not count against the above statements concerning the ability to determine in advance the probable yield of a well, to find that neighboring wells, similarly constructed, yield very different amounts of water, or that water can not be obtained a short distance from a good well. Such a discovery always causes considerable comment, while the numerous cases in which ground water is found at very uniform depths and in nearly identical material call forth no comment whatever.

The amount of water yielded by a common open well or by a non-flowing tubular well is dependent first of all upon the degree of fineness of the material in the various strata from which the water is obtained. The size of the soil grains not only controls the rate at which water can be transmitted to the well under a given head, but it also determines the proportion of contained water which the soil will freely part with. The fine-grained soils retain a considerable proportion of the water of saturation as capillary water even after free means of drainage are established, so that fine-grained material will not only deliver water

slowly, but will furnish only a small total amount. Some quicksand is so fine that the water can be pulled away from the fine grains with the greatest difficulty, while silt with a diameter of grain of about one one-thousandth of an inch (not at all an unusual size) will part with its water very slowly even when it is placed on a piece of blotting paper.

The above factor in the specific capacity of the well can be expressed by means of the transmission constant, k, of the material furnishing the water. Other things being equal, the yield of the well will vary directly with the transmission constant.

Another cause effecting the yield of the well is the thickness of the water-bearing stratum. If the transmission constants of all water-bearing strata are the same, the amount of water available is directly dependent upon the thickness of strata penetrated, provided, of course, that only such material is counted as is in contact with a suitable well screen or strainer.

An important factor in determining the yield of a well is the diameter of the well. By the diameter is meant the diameter of the well where it penetrates the water-bearing stratum. The diameter of the well is a factor which determines the rate at which the water must move in the water-bearing material as it enters the well. A well having a large casing will permit a given amount of water to enter under a low velocity, and hence with little friction in the pores of the water-bearing medium. The dependence of the yield upon the diameter of the well is not expressible in a very simple way. In fine material, the dependence of the yield upon the diameter of the well is very much less than is commonly supposed. Only in material that is very coarse is it usual that any great advantage is obtained by using casing as large as 16 to 24 inches in diameter.

The friction of the water as it flows upward in the casing of a well, a factor which is often very large in the case of an artesian well, is usually small or negligible in common tubular wells from which the water is pumped with a suction pipe much smaller than the diameter of the well itself. This statement must not be understood to imply that the amount of water discharged by the pump is not influenced by the size of the suction and discharge pipes. What is meant is that, with a given lowering of the water in the well the yield of water will not be dependent upon the friction in the casing to the upward-moving water, while of course the amount of power applied to the pump will be greatly influenced by the size of the suction and discharge pipe and upon the manner in which these pipes are installed.

Finally, the specific capacity, if the well be not too shallow, varies directly as the distance the surface of the water in the well is lowered by pumping. Thus, if the water in a well is lowered 2 feet below the natural level by pumping from it at the rate of 20 gallons a minute, the same well may be expected to yield approximately 40 gallons a

minute if the water is lowered 4 feet below the natural level. For shallow wells the yield will not increase in this direct ratio, but will be considerably less on account of the decrease in percolating surface due to the lowering of the water plane in the neighborhood of the well. Besides the advantages just mentioned, tubular wells, owing to their greater depth, are much more likely to strike a vein of coarse material, a small stratum of which may be expected to furnish much more water than a considerable depth of fine material. This accounts for the well-known superiority of deep tubular wells over common dug wells.

If a well be cased through the water-bearing medium, the character of the screen or perforations in the casing will of course influence the yield of the well. If a screen is clogged, or if the perforations are not ample, the capacity of the well will be cut down because of this imperfect casing.

All of the factors named above influence the yield of a flowing artesian well, except that in place of the distance the water is lowered by pumping we must substitute the static head at the point of discharge of the flowing water. By the static head is meant the pressure when the well is closed at the point at which the flow is measured. This static head is conveniently expressed in terms of feet of water. For example, instead of giving the static head in pounds per square inch we can state it in feet of water. The flow of water from the porous medium into the well will vary directly as the static head, but the total yield of the well will not vary in this simple way on account of the frictional resistance which the water suffers in flowing through the casing and drill hole of the well. This last component of the specific capacity while usually small in a well that is pumped is often of the very first importance in the case of a flowing well. To the friction in the casing and discharge pipe should be added the influence of all turns and bends and reductions in size and the like. This factor is often a very large one in the determination of the amount of water yielded by an artesian well. The resistance due to friction increases very greatly with a decrease in the size of pipe and also with an increase in the length of the pipe, and is materially influenced by the curves and variations in size of the pipe and by the rivets and joints in the well casing or discharge pipes. The friction in pipes does not vary directly with the hydraulic head, but approximately as the square root of the head at which the flow takes place.

As stated before, complete data concerning tubular wells are very difficult to obtain. Complete data concerning an artesian well should consist of the following: First, exact dimensions of all casing and sizes of the bore hole, including, of course, total depth; second, the static head of the well measured at a point a known distance above the surface of the ground; third, an accurate measurement of the amount of

The rate of rise of the water surface in the well after it has been depressed by pumping should furnish a very smooth and regular curve when plotted on cross-section paper. The law of this curve is such that if at the end of a certain period of time (say fifteen minutes) the depression of the water surface in the well is half of the original amount of depression just before pumping ceased, then at the end of twice that period of time (thirty minutes) the depression will be one-fourth of the original amount; at the end of thrice that period of time (forty-five minutes) it will be one-eighth of the original amount, etc. Four curves of rise of water in wells are given in fig. 61. Curves 3 and 4 are from the same well, but during the rise shown by 4 a neighboring well 20 feet distant was being pumped.

The theoretical law of rise of water in a well can also be expressed by a formula, as follows:

$$t = \frac{17.25\,A}{c} \log \frac{h}{H}$$

In this formula A is the area in square feet of the cross section of the well casing, counting out the area of the pump rod, suction pipe, or other obstruction. H is the amount in feet that the surface of the water in the well was depressed below its natural level just before pumping stopped; c is the specific capacity of the well expressed in gallons per minute; h is the amount in feet of depression of the water surface below the natural level at any time t (in minutes) after pumping ceased. By taking two corresponding values of h and t from the curve of rise of water surface, the specific capacity of the well (c) can easily be computed from the formula

$$c = 17.25 \frac{A}{t} \log \frac{h}{H} \text{ gallons per minute.}$$

Examples of use of this formula will be given below (p. 93). The logarithm indicated by "log" is the common or Briggs logarithm.

The following reports of tests on small wells used for irrigation illustrate the importance of accurate tests of this kind and indicate the sort of information that it is desirable to secure. The first test shows a well-constructed plant giving fair service. The second plant shows a well-constructed plant, but indicates not only an inefficient style of pump, but showed an expensive waste of gasoline through a hidden leak in the feed pipe.

TESTS.

TEST I. ON WELL AND GASOLINE PUMPING PLANT OF D. H. LOGAN, GARDEN, KANS.

This plant is located on the northeast corner of sec. 13, T. 24 S., R. 33 W., and is in the northwest corner of the city of Garden. The outfit consists of a 6-horsepower Fairbanks, Morse & Co., horizontal

There is a windmill 20 feet north of the well pumped by the engine, a 12-foot aermotor connected to a 10-inch pump of 12-inch stroke. After the weir measurements were completed the windmill was thrown into gear. There was a brisk wind from the south and the pump threw a good quantity of water, but no appreciable lowering of the water was detected in the well being tested 20 feet away. The rise of the water in the well was obtained twice.

Below are the two sets of observations:

First trial; windmill not running.			Second trial; windmill running.		
Minutes.	Seconds.	Stopped pumping.	Minutes.	Seconds.	Stopped pumping.
0	55	18.60	24	30	.....
1	05	16.05	.....	35	18.0
1	20	14.55	.....	45	16.5
1	37	12.95	.....	48	14.35
1	55	12.50	25	10	13.10
2	8	12.35	.....	26	12.90
.....	22	12.35	.....	38	12.55
.....	33	12.25	.....	48	12.55
.....	48	12.15	26	00	12.45
			.....	23	12.25
			.....	47	12.25
			.....	58	12.25
			27	15	12.25
			.....	30	12.25

The curves showing the rate of rise of water in the Logan well after pumping ceased are given by curves 3 and 4 in fig. 61. The curve 4 is the one which was produced when the windmill was pumping from a well 20 feet from the one for which the curve is drawn. The comparison of this curve with curve 3, which was produced when the neighboring well was not used, is very interesting, showing as it does a less rapid rise when the neighboring well was in use. To find the specific capacity for the Logan well from these curves we must substitute the values of the various constants in the formula

$$c=17.25\,\frac{A}{t}\log.\frac{H}{h}\text{ gallons per minute.}$$

The value of A, the area of cross section of the well casing, is 2.17 square feet, and of H, the amount the water is lowered by the pump, 6.85 feet. The amount of depression h of the water level below the

natural level at any time can then be selected from the curve and the specific capacity readily computed. If t be taken to be forty seconds, or two-thirds minute, h will be found from the curve to equal 6.85–5.5=1.35 feet, hence

$$c=17.25\times\frac{3}{2}\times 2.17\times\log\left(\frac{6.85}{1.35}\right)\text{ gallons per minute.}$$
$$=39.5\text{ gallons per minute.}$$

The yield of the well for the maximum depression, 6.85 feet, must then be

$$6.85\times 39.5=270\text{ gallons per minute.}$$

The curve of rise of water forms one of the best methods of determining the yield of a well. Such curves can readily be obtained.

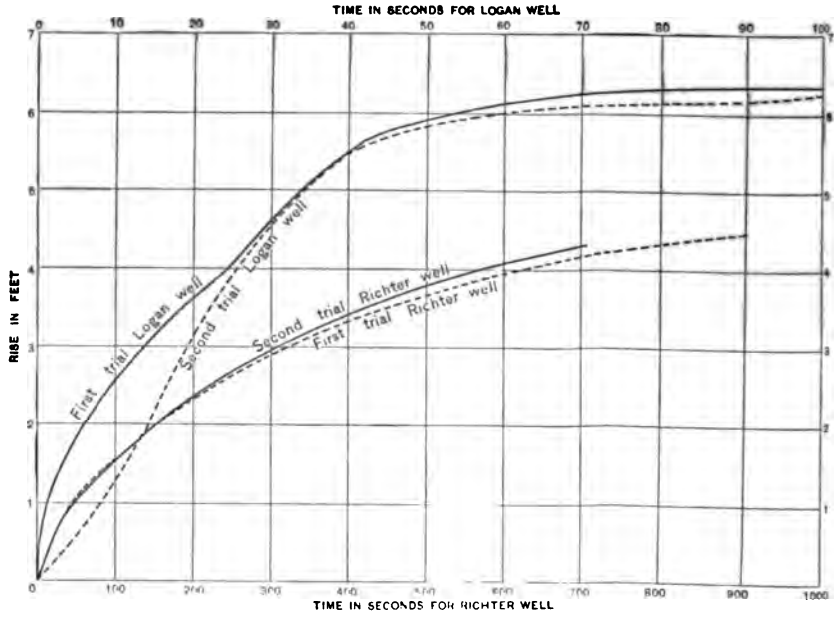

TIME IN SECONDS FOR LOGAN WELL
RISE IN FEET
First trial Logan well
Second trial Logan well
Second trial Richter well
First trial Richter well
TIME IN SECONDS FOR RICHTER WELL

FIG. 61. Curves showing the rate of rise of water in the Richter and Logan wells near Garden, Kans. Curve 1 (dotted), first trial of Richter well; curve 2 (solid), second trial of Richter well; curve 3 (solid), first trial of Logan well; curve 4 (dotted), second trial of Logan well.

Well data should always include measurements of the amount of lowering of the water surface by the pumps, and it is only necessary to continue these measurements after the pumps have stopped to secure sufficient data to estimate the specific capacity and total yield of the well. This avoids the necessity of constructing a weir or other method of measuring the water discharged. The accuracy is sufficient for the purpose for which such data are used.

TEST II. ON WELL AND GASOLINE PUMPING PLANT OWNED BY MINNIE RICHTER, FINNEY COUNTY, KANS.

This plant is located in the northwest corner of the SW. ¼ sec. 14, T. 24 S., R. 33 W. The upper part of this well is cased with part of an old standpipe from the city of Garden. The casing is 10 feet in diameter and extends down 20 feet. In the bottom of this part of the well are placed four 8-inch galvanized-iron feeders, arranged symmetrically about the center. Each feeder is 25 feet long, perforated its entire length, and extends about 2½ feet above the bottom of the large part of the well.

The pump used operates on the principle of a screw propeller of a steamship. It bores the water out and up a square wooden penstock or pump shaft. There are two of these propellers, mounted one above the other on a vertical iron shaft inside the penstock. The top of the iron shaft carries the belt pulley and has a shoulder bearing which takes the thrust of the pump. This pump (called the Menge) is made in New Orleans. The pump is run by a 10-horsepower Otto gasoline engine, which runs at a speed of 300 revolutions per minute. The circumference of the drive pulley is 5.25 feet and of the driven pulley 2.65 feet, making the pump run at 595 revolutions per minute. The screws are under water when the pump is not in operation. A small pond was constructed at the end of the discharge trough, and a fully contracted rectangular weir of length of crest of 1.2 feet was used to measure the discharge. The measurements for head were taken 6 feet away from the weir, and boards were interposed between the discharge trough and weir to cut down the velocity which might tend to give erroneous results. The average corrected head on the weir was 0.371 feet. Using the weir formula

$$q = c\,\tfrac{2}{3}\sqrt{2g}\,b\,H^{\frac{3}{2}},$$

and, taking c from Merriman's tables as 0.603,

$$q = 0.876 \text{ second-feet},$$
$$= 394 \text{ gallons per minute},$$

or using Francis formula

$$q = 3.33\,(b - 0.2\,H)\,H^{\frac{3}{2}},$$
$$= 314 \text{ gallons per minute}.$$

Using a small Price acoustic water meter in the discharge trough, by measuring the velocity at different places, and also by integrating, the discharge was found to be 0.76 second-feet = 342 gallons per minute. By putting chips in the discharge trough and catching the time with a stop watch, the surface velocity was found to be 1.565 feet per second. This multiplied by 0.8 gives an average velocity of 1.25 feet per second and a discharge of 0.884 second-feet = 397 gallons per minute.

An attempt was made to determine the amount of gasoline used. The reservoir was filled full and the engine run for one hour and thirty-six minutes, or 1.6 hours. All the gasoline we had, 9¼ quarts, did not

then fill the tank. This was at noon, July 6. On the morning of July 7, 9½ quarts were required to completely fill the reservoir, a total of 18¾ quarts or 37½ pints for the run of 1.6 hours for a 10-horsepower engine. The makers claim that their engines use 1 pint per horsepower hour. This would require in this case 16 pints, or less than half of what was actually measured, if the engine developed its full horsepower. A leak in the tank or feed pipe is clearly indicated. This fact, while being of value to the owner of the plant, shows the record to be worthless as far as comparative cost of pumping is concerned.

Two observations of the rising curve were obtained which agree very well. The lower part of the curve is not accurate because the water in the penstock drops back into the well when pumping ceases.

	Feet.
The elevation of the ground at well is	2,846.0
Average elevation of water in well	2,836.6
Average elevation of water in well when pumping	2,831.5
Elevation of discharge from penstock	2,847.0
Lift	15.5
Average amount water is lowered	5.3

Number of explosions of engine, 126.5 per minute.

The curves of rise for this well were obtained on two different occasions, and are shown as curves 1 and 2 in fig. 61. They agree very well. To find the specific capacity of the well from the curve, we note the following values of the constants in the formula for specific capacity:

$$c = 17.25 \frac{A}{t} \log \frac{H}{h} \text{ gallons per minute.}$$

The area, A, of cross section of the well casing is 76.79 square feet. The amount, H, that the water is lowered by the pump is 5.3 feet. The amount of depression, h, of the water surface below the natural level at any time can be selected from the curve. From the curve, at the close of ten minutes, h equals 5.3 − 4 = 1.3 foot. Hence the specific capacity,

$$c = 17.25 \times \frac{76.79}{10} \log \frac{5.3}{1.3} = 81 \text{ gallons per minute.}$$

Multiplying by 5.1, the head under which pumping took place, the total yield of the well is 81 × 5.3 = 429.3 gallons a minute.

The above determination of the specific capacity is inaccurate, since the first portion of the rising curve does not show the true rate of rise of water in the well. The penstock of the propeller pump holds 37.7 cubic feet of water, which immediately returns to the well when the pump is stopped. This amount of water is sufficient itself to raise the level in the well by 0.465 foot. For this reason only that portion of the rising curve should be used which is uninfluenced by the return-

ing water from the penstock. Thus, if we use that part of the curve from $t=100$ seconds to $t=600$ seconds, we will eliminate the inaccurate portion. By this modification the data are changed to H=3.75 feet; $h=1.30$ feet; $t=\frac{8}{9}$ minute. Computing the specific capacity on this basis we obtain $c=73$ gallons per minute. This multiplied by 5.3 gives the total estimated yield 388 gallons per minute, which checks more nearly with the 394 gallons per minute previously obtained.

The area of the surface of the strainers and the bottom of the well is 266.5 square feet. The above specific capacity divided by 266.5 gives .341 gallon per minute as the specific capacity per square foot of percolating surface.

The engine ran at a speed of 300 revolutions per minute and exploded 125 times per minute. This would indicate that it was working at about 83 per cent of its rated capacity. Assuming that such was the case, and that it would then use 83 per cent of the fuel necessary to run it at is full rated power (10 horsepower), we have 8.3 pints as the probable amount of gasoline used per hour by the engine during the test. This, at 20 cents per gallon, would make a cost of 21 cents per hour. This assumption makes the cost of water 0.89 cent per 1,000 gallons, $2.90 per acre-foot, and one-seventeenth cent per 1,000 foot-gallons.

CHAPTER VIII.

THE CALIFORNIA OR "STOVEPIPE" METHOD OF WELL CONSTRUCTION FOR WATER SUPPLY.

MODE OF CONSTRUCTION.

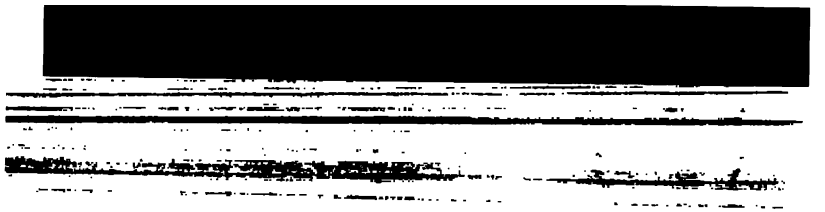
The peculiar conditions of water supply existing in southern California have led to the development of a special type of well, which the writer believes to be admirably adapted to conditions found in many places in the various parts of the United States. It is hoped that the following account will call the attention of those interested in recovering ground water in large quantities to the many points of excellence of the California type of well and method of well construction.

The valleys of southern California are filled with deposits of mountain débris, gravels, sands, bowlders, clays, etc., to a depth of several hundred feet, into which a considerable part of the run-off of the mountains sink. The development of irrigation upon these valleys soon became so extensive that it was necessary to supplement more and more the perennial flow of the canyon streams by ground water drawn from wells in the gravels. This necessity was greatly accentuated by a series of dry years, so that ground waters became a most valuable source of auxiliary supply for irrigation in the important citrus areas in southern California. The type of well that came to the front and developed under these circumstances is locally known as the "stovepipe" well. It seems to suit admirably the conditions prevailing in southern California. In developing water supply for irrigation the item of cost is of course much more strongly emphasized than in developments for municipal supply. The drillers of wells in California were confronted not only with a material which is almost everywhere full of bowlders and like kinds of mountain débris, but also with a high cost of labor and of well casings. It was undoubtedly these difficulties that led to the very general adoption in California of the stovepipe well.

The wells are put down in the gravel and bowlder mountain outwash, or other unconsolidated material, to any of the depths common in other localities. One string of casing, in a favorable location, has been put down over 1,300 feet. The usual sizes of casings are 8, 10, 12, 14 inches, and even larger. A common size is 12 inches. The well casing consists of: First, a riveted sheet steel "starter" 15 to

A. TWELVE-INCH STOVEPIPE STARTER.

B. TWO LENGTHS OF STOVEPIPE CASING.



eet long, made of two or three thicknesses of No. 10 sheet steel, ı a forged steel shoe at the lower end. Pl. XII, *A*, shows a ter 21 feet long, made of double No. 10 sheet steel, with a ¾- by 8- 12-inch steel shoe riveted on the bottom. In ground where large vlders are encountered the starters are made heavier, the shoe is ıch thick and 12 inches long, and three-ply instead of two-ply No. 10 ;et steel body is used.

Above the starter, the rest of the well casing consists of two thicksses of No. 12 sheet steel made into riveted lengths, each 2 feet long. ıe set of sections is made just enough smaller than the other so that ıe length will telescope snugly inside of the other. Each outside ction overlaps the inside section 1 foot, so that a smooth surface :sults both outside and inside of the well when the casing is in place, ıd so that the break in the joints is always opposite the middle of a -foot length. It is these short, overlapping sections which are popuırly known as "stovepiping." A pile of this casing ready for use is hown in Pl. XIII, *A*, and two lengths are shown on a larger scale in Pl. XII, *B*. The sheets of steel can be taken to the field flat and the :iveting done during the process of well construction.

The casing is sunk by large steam machinery of the usual oil-well type, but with certain very important modifications. The well rig shown in Pl. XIII has a derrick with mast 40 feet high. When ready to move, the mast swings backward on hinges with the top resting on upright at the rear end of the rig, as shown in fig. 63. Jackscrews are placed under the sills and the whole machine is raised sufficiently to allow wheels to be placed on two axles bolted to the sills. The photograph reproduced in Pl. XIII also shows a 25-horsepower boiler mounted on separate trucks. The 10-inch sand pump and jars are shown just as they have been pulled out of a 12-inch well.

In ordinary material the "sand pump" or "sand bucket" is relied upon to loosen and remove the material from the inside of the casing. The casing itself is forced down, length by length, by two or more hydraulic jacks, buried in the ground and anchored to two timbers 14 inches square and 16 feet long, planked over and buried in 9 or 10 feet of soil. These jacks press upon the upper sections of the stovepiping by means of a suitable head. In Pl. XIII, *B*, the clevises of the pistons of the hydraulic jacks can be seen hooked over the ears of the well cap. The jacks, whose clevises appear in the cuts, have 8-inch piston and 4½-foot stroke, and a combined pull of about 120 tons. The driller, who stands at the front of the rig, has complete control of the engine, hydraulic pump, and valves by which pistons are moved up or down, and also of the lever which controls two clutches which cause tools to work up and down or to be hoisted. The hydraulic pump is mounted upon the main frame of derrick, as shown in Pl. XIV, *B*. The one shown is a Marsh pump with a steam cylinder of 8

diameter, and water cylinder of 1¾-inch diameter with 12-inch stroke. It is coupled to the jacks with extra strong ¾-inch hydraulic pipe and fittings. Smaller rigs use a pump with 6½-inch steam by 1¾-inch water cylinders, 10-inch stroke, and coupled to jacks with ½-inch pipe. A boiler pressure of 100 pounds puts nearly a limiting stress on the ½-inch pipe and it sometimes breaks.

The sand pumps used are unusually large and heavy. For 12-inch work they will vary in length from 12 to 16 feet, 10⅜ inches in diameter, and will weigh, with lower half of jars, from 1,100 to 1,400 pounds.

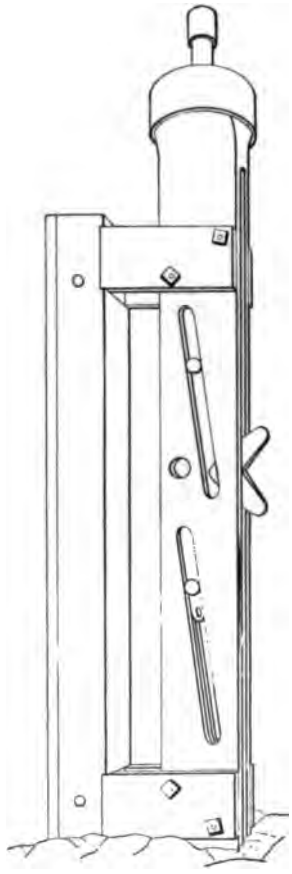


Fig. 62.—Roller type of perforators for slitting stovepipe wells. This perforator was used for cutting 60 feet of screen in the wells shown in Pl. XV.

After the well has been forced to the required depth, a cutting knife is lowered into the well and vertical slits are cut in the casing where desired. A record of material encountered in digging the well is kept, and the perforations are made opposite such water-bearing strata as may be most advantageously drawn upon. A well 500 feet deep may possess 400 feet or more of screen if circumstances justify it.

Pl. XIV, *A* shows the perforator for slitting stovepipe casing. It is handled with a 3-inch standard pipe with ¾-inch standard pipe on the inside. The perforator is shown in cutting position with knife extended. In going down or in coming out of the well the weight of ¾-inch line holds point of knife up. When ready to "stick" the ¾-inch line is raised. By raising slowly on 2-inch line with hydraulic jacks, cuts are made three-eighths inch to three-fourths inch wide and 6 to 12 inches long, according to the material at that particular depth.

Fig. 62 shows another type of perforating knife. The revolving cutter punches five holes at each revolution of the wheel. This style of perforator is called a "rolling knife." By means of this tool 60 feet of perforations were cut in the well shown in Pl. XV.

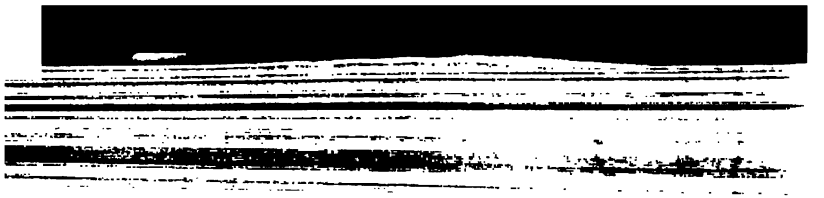
A great many different kinds of perforators are in use in California; in fact, the perforator is a favorite hobby of local inventors. The different patterns in use seem to work well. Those shown in the illustrations are very good.

A

B

CALIFORNIA WELL RIG.

A, Side view; *B*, Front view, showing clevises of hydraulic jacks hooked over ears of well cap.



ADVANTAGES OF "STOVEPIPE" CONSTRUCTION.

he advantages of this method of well construction are quite obvious. · wells in unconsolidated material the California type is undoubt- y the best yet devised. It is believed that wells of this type would highly successful in the unconsolidated deposits in other localities. e absence of bowlders and very coarse gravels in some deposits may ssibly make it more advantageous to use the hydraulic jet instead of ponderous sand bucket in soft material, but this is the only modi- ation that these conditions seem to suggest.[a]

Among the special advantages in the stovepipe construction may enumerated the following:

1. The absence of screw joints liable to break and give out.
2. The flush outer surface of the casing without couplings to catch n bowlders or hang in clay.
3. The elastic character of the casing, permitting it to adjust itself n direction and otherwise to dangerous stresses, to obstacles, etc.
4. The absence of screen or perforation in any part of the casing vhen first put down, permitting the easy use of sand pump and the enetration of quicksand, etc., without loss of well.
5. The cheapness of large-size casings because made of riveted sheet teel.
6. The advantage of short sections, permitting use of hydraulic jacks n forcing casing into the ground.
7. The ability to perforate the casing at any level at pleasure is a lecided advantage over other construction. Deep wells with much creen may thus be heavily drawn upon with little loss of suction head.
8. The character of the perforations made by the cutting knife are he best possible for the delivery of water and avoidance of clogging. The large side of the perforation is inward, so that the casing is not ikely to clog with silt and débris
9. The large size of casing possible in this system permits a well to e put down in bowlder wash where a common well could not possibly e driven.
10. The uniform pressure exerted by the hydraulic jacks is a great dvantage in safety and in convenience and speed over any system hat relies upon the driving of the casing by a weight or ram.
11. The cost of construction is kept at a minimum by the limited mount of labor required to man the rig as well as by the good rate f progress possible in what would be considered in many places mpossible material to drive in, and by the cheap form of casing.

COST OF CONSTRUCTION.

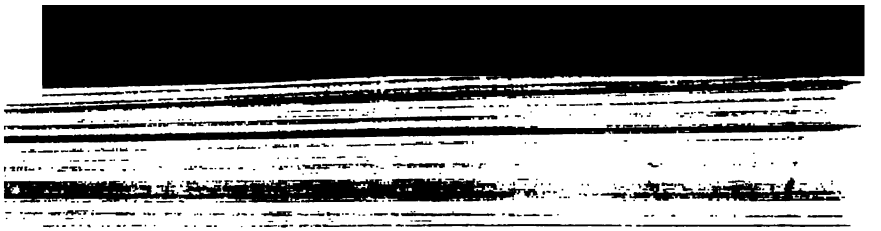
An idea of the cost of construction of these wells can best be given y quoting actual prices on some recent construction in Californi

[a] A 12-inch stovepipe well was sunk to a depth of 2,800 feet on the Lanoria Mesa, 7 miles north f El Paso, Tex. The last 2,000 feet was drilled in dry clay by use of a powerful hyd-

A. PERFORATOR FOR SLITTING STOVEPIPE CASING.

B. REAR VIEW OF CALIFORNIA WELL RIG.

Showing engine and hydraulic pump.



in the cut it has just finished a 12-inch well which flows 404 miner's inches, or about 5,250,000 gallons per twenty-four hours. This well is 848 feet deep and has about 60 feet of perforations. Mr. Proctor used four hydraulic jacks in sinking this well, developing a pressure of 160 to 200 tons.

YIELD OF WELLS.

It is not very profitable to name individual wells of this type and give their yield, since conditions vary so much from place to place. From the method of construction it must be evident that this type of well is designed to give the very maximum yield, as every water-bearing stratum can be drawn upon. The yield from a number of wells in California of average depth of about 250 feet, pumped by centrifugal pumps, varied from about 25 to 150 miner's inches, or from 300,000 to 2,000,000 gallons a day. These are actual measured yields of water used for irrigation.

Among the very best flowing wells in southern California are those near Long Beach. The Boughton well, the Bixby wells, and the wells of the Sea Side Water Company are 12-inch wells varying from 500 to 700 feet in depth and flowing about 250 miner's inches each, or over 3,000,000 gallons per twenty-four hours. The well shown in Pl. XV is located about 4 miles northeast of Long Beach and its flow is the greatest yet reported.

Among the records of depth are those of 1,360 feet for 10-inch well and 915 feet for 12-inch well. Mr. Proctor has bored a 14-inch well more than 704 feet in depth.

CHAPTER IX.

TESTS OF TYPICAL PUMPING PLANTS.

In connection with the general discussion of movement of underground waters it has been thought that a few descriptions of characteristic tests of pumping plants would be of interest and value. With this idea in view a number of typical plants, including several different classes, have been selected from the large number examined and descriptions of the tests prepared.

The Felix Martinez pumping plant is run by electric power and gives a good chance to see what can be done with combination of centrifugal pump and electric motor in the recovery of water for irrigation. The pumping plant of J. A. Smith is of special interest on account of a very low cost of power, due to the use of petroleum gas generated from crude oil. The test of Roualt's pumping plant is of great interest on account of the use of steam engine with wood as fuel. The wood was obtained at a very low price per cord, yet the showing in the cost per acre-foot will not compare with the plants that use gasoline engines with gasoline at 17 cents a gallon. The last pumping plant reported upon, that of the Horaco Ranch Company's well No. 1, is of special interest on account of the all-around excellence and efficiency of the plant. The table that is inclosed summarizes the results at all of the plants and gives items of cost.

TEST OF PUMPING PLANT OF FELIX MARTINEZ NEAR EL PASO, TEX.

The pumping plant on the ranch of Mr. Felix Martinez, of which a test was made, is located near the main county road east of El Paso, about 3 miles from the court-house. The plant consists of a No. 5 Byron Jackson horizontal-shaft centrifugal pump, run by a General Electric 10-horsepower direct-current motor, type C. E., class 4. The pump is located in a pit, and is connected to a 6-inch well. The well is 68 feet deep, measured from the surface of the ground, and has 10 feet of perforated or slotted galvanized-iron strainer at the bottom. The gravels were reached at a depth of 56 feet, and consisted of fairly large gravel, containing a large quantity of fine sand. The pump is connected with the well by a 5-inch suction pipe and discharges through a vertical and horizontal 5-inch discharge pipe into a rectangular flume. The discharge was measured by integrating with a Price acous-

c current meter in the rectangular flume. The average depth of ater at the cross section of flume where measurements were taken as 0.475 foot. The average width of flume was 0.992 foot, giving an rea of 0.470 foot. The mean velocity of the water at the selected

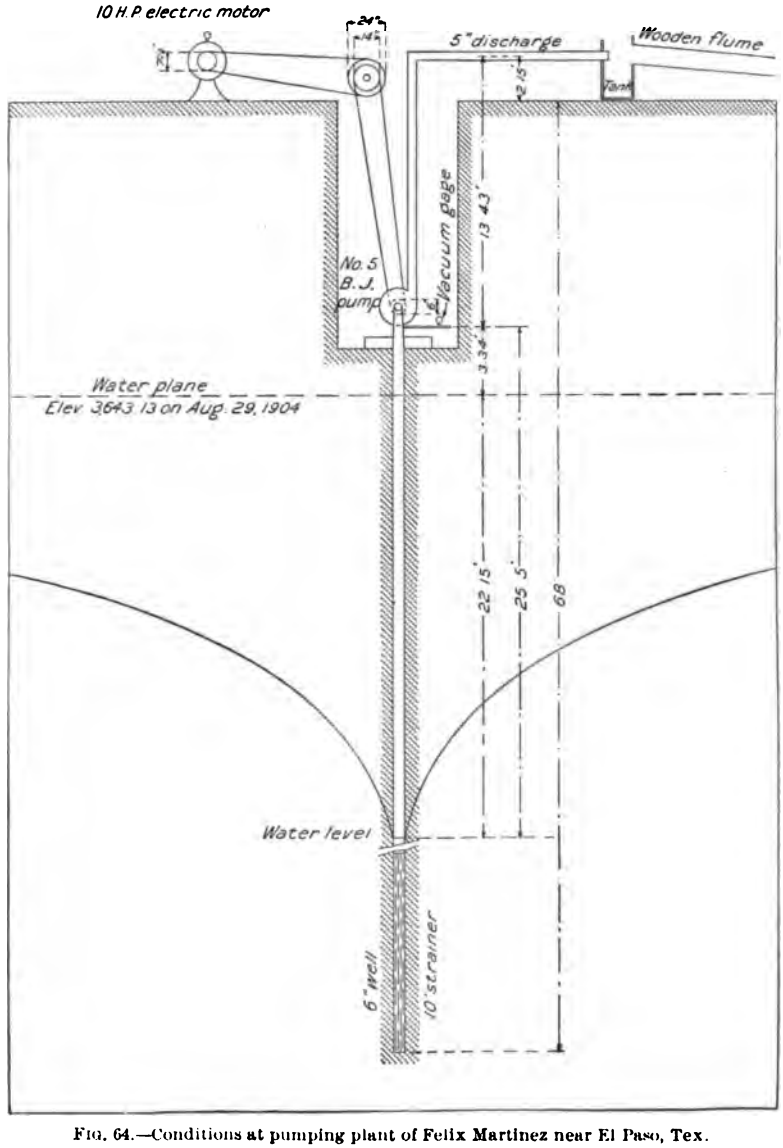


FIG. 64.—Conditions at pumping plant of Felix Martinez near El Paso, Tex.

cross section was 1.78 feet per second, giving total discharge of 0.838 cubic foot per second, or 378 gallons a minute.

The vacuum gage was attached to the goose neck of the centrif[redacted] pump. The vacuum shown after a few minutes pumping[redacted]

coarse gravel containing much fine material was encountered. There was only 12 feet of this coarse gravel. Ten feet of slotted galvanized-iron strainer with hit-and-miss slits was placed at the bottom of this well. The east well is 6 inches in diameter and 73 feet deep. The gravel at this point was found to be 22 feet deep. A 16-foot slotted strainer was used in this well. The west well is also a 6-inch well and is 61 feet deep. The gravel was found to be 11 feet deep, and a 10-foot slotted strainer was used in the well. All of the strainers have $\frac{3}{16}$-inch by $1\frac{1}{2}$-inch slots, or perforations. The horizontal 8-inch suction pipe, which extends from the central well to the east and west wells, is 14 feet below the top of the ground.

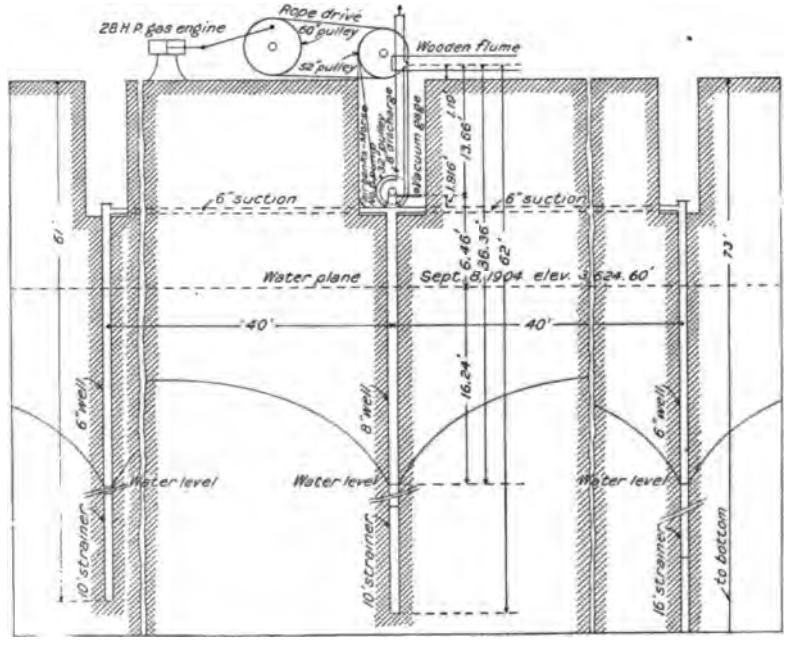


FIG. 65.—Conditions of pumping plant of J. A. Smith, near El Paso, Tex.

The water is pumped by a No. 6 Fairbanks-Morse horizontal-shaft centrifugal pump, connected with rope drive to a 28-horsepower gasoline engine, with crude oil gas generator attached. The fact that the engine is run by producer gas generated from Texas crude petroleum renders this plant of especial interest. The fuel cost relative to the amount of water recovered is the lowest that the writer has recorded for a small plant. The crude oil gas generator has been in operation several months, running continuously day and night, except for a cleaning each week or two. When the generator is kept clean there is little trouble from carbon passing from the generator into the cylinder of the engine and cutting out the cylinder and packing. The plant must be pronounced a decided success, as the further account to be given

and the cost of 1,000 foot-gallons was one one hundred and seventy-first of a cent.

The cost of the water at the same plant, when pumped with gasoline, was also determined. A test of eleven hours' run with same engine, using gasoline instead of crude oil gas, consumed 40 gallons of gasoline, or 3.64 gallons per hour. At 14 cents a gallon, the hourly cost for gasoline was $0.51, which makes the cost of each 1,000 gallons of water pumped $0.0092. The cost per 1,000 foot-gallons was $0.000236, or one forty-second of a cent.

The above estimates do not represent, of course, the total cost of pumping, as no items have been included to cover interest, depreciation, labor, etc.

The 926 gallons a minute furnished by the above plant amounts to a little over 2 second-feet, or 4 acre-feet per twenty-four hours. The cost of fuel per acre-foot of water was, therefore, 73 cents when using crude oil, and $2.99 an acre-foot when using gasoline at 14 cents a gallon.

TEST OF ROUALT'S PUMPING PLANT NEAR LAS CRUCES, N. MEX.

A test was made at the pumping plant of Theodore Roualt, located on a ranch about 3 miles northwest of Las Cruces, N. Mex. Water is obtained from a 10-inch well, 48 feet deep, containing 10 feet of 9¾-inch slotted galvanized-iron strainer. Water is recovered by a No. 3 Van Wie vertical-shaft centrifugal pump, driven by a 10-horsepower Nagle steam engine, on 18-horsepower horizontal wood-burning boiler. The engine is directly belted to pump shaft by means of 30-inch driving and 12-inch driven pulley. The water is discharged through an 8-inch vertical discharge pipe into a rectangular flume.

The speed of engine was 205 revolutions per minute, and that of the pump was 525. The steam pressure varied between 81 and 83 pounds. The distance from vacuum-gage tap to the water plane was 3.64 feet. The distance of vacuum-gage tap to top of bottom plank of flume was 7.96 feet, and from tap to top of water jet the distance was 8.66 feet.

The vacuum gage read 24.25 inches, which is equivalent, when corrected for altitude, to 22.25 inches of mercury, or 25.5 feet of water, making the total lift 34.16 feet. The discharge was measured by integrating with a Price acoustic current meter in the rectangular flume. The width of flume was 1.19 feet and the average depth of water at the selected cross section was 0.35 foot, giving a cross section of 0.417 square foot.

The average velocity of the water at the selected cross section was 1.867 feet per second, which gives a discharge of 0.78 second-foot, or 351 gallons a minute. From this we deduce the specific capacity of the well to be 16.3 gallons a minute, and the specific capacity for each square foot of well strainer is 0.627 gallon a minute.

The cost of fuel used for pumping can be readily estimated from careful tests by Mr. Roualt. For one irrigation of a 70-acre field of tomatoes, twenty-eight days of twenty-four hours were required, and

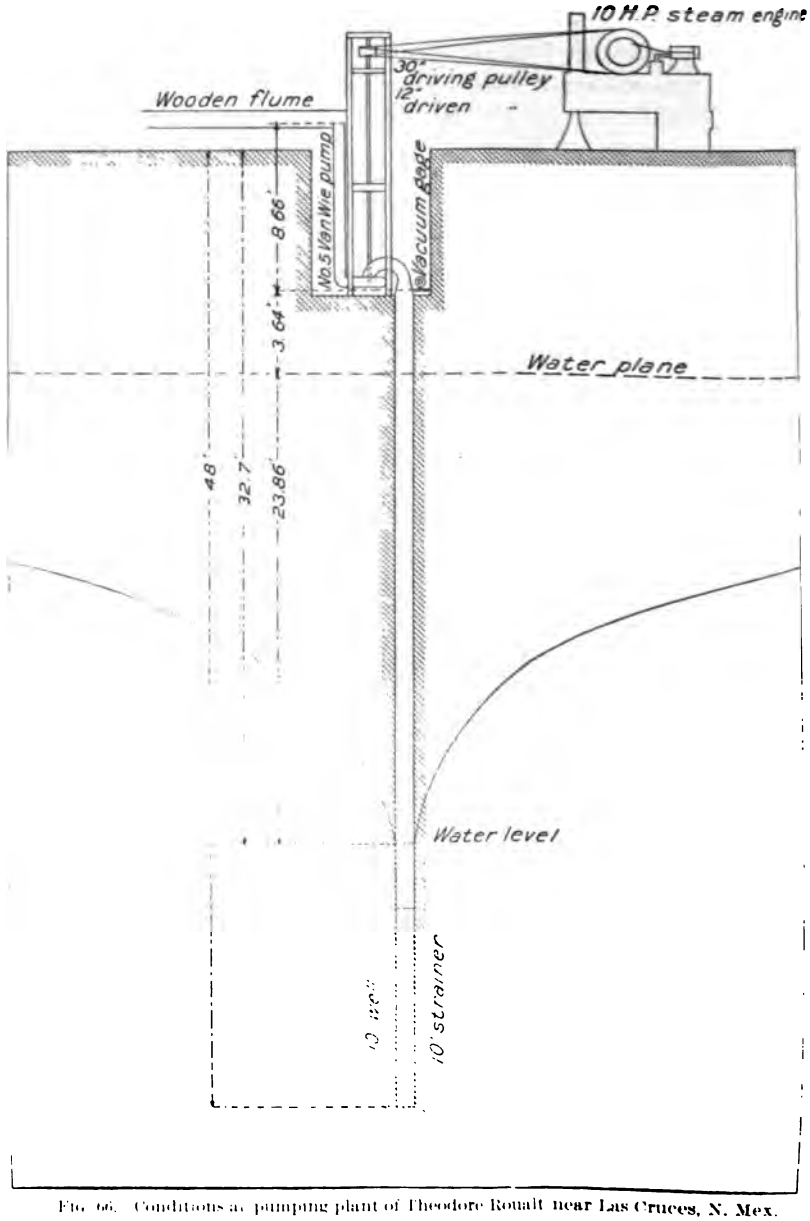


FIG. 66. Conditions at pumping plant of Theodore Roualt near Las Cruces, N. Mex.

75 cords of cottonwood were consumed by the engine, costing $2 per cord. During the twenty-eight days of twenty-four working hours each, 14,150,000 gallons, or 43.5 acre-feet, of water were pumped.

he total cost of wood being $120, the fuel cost per 1,000 gallons of ater recovered was $1.06, or $3.45 per acre-foot. The fuel cost per ,000 foot-gallons was $0.00031, or about one thirty-second of a cent.

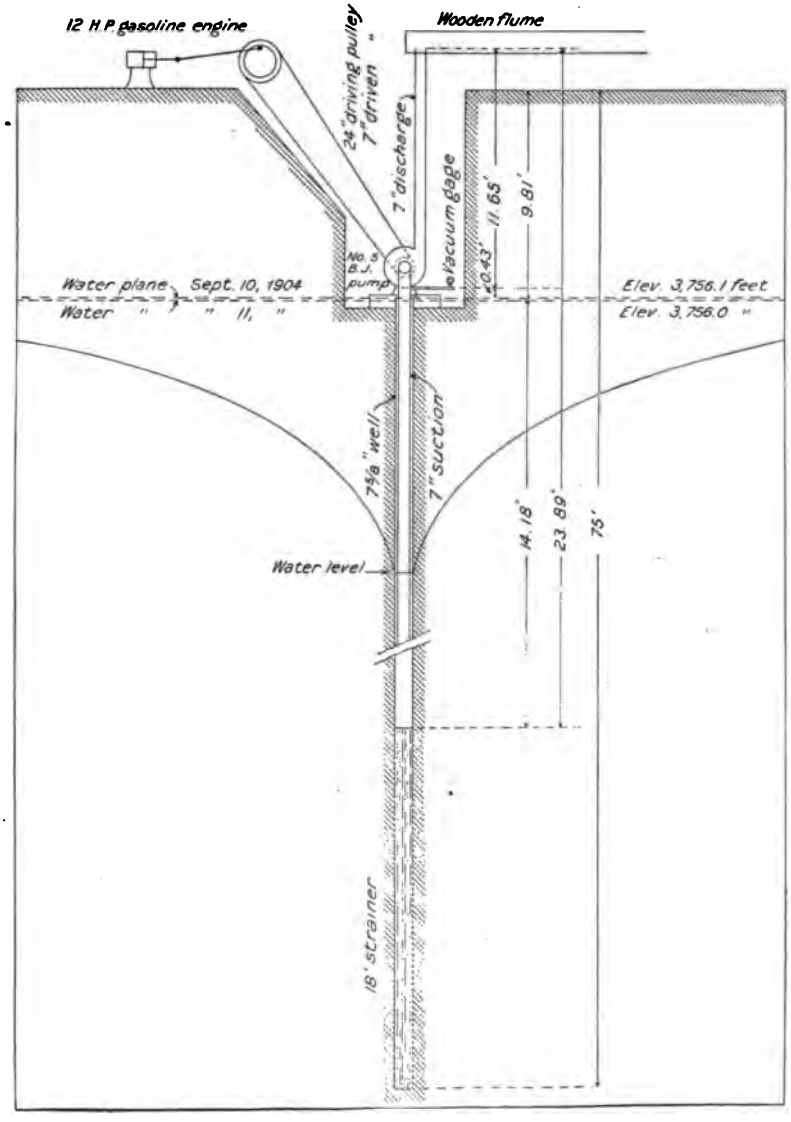


FIG. 67.—Conditions at Horaco Ranch Company's well No. 1, at Berino, N. Mex.

TEST OF HORACO RANCH COMPANY'S WELL NO. 1, BERINO, N. MEX.

Well No. 1 of the Horaco Ranch Company, at Berino, N. Mex., is 75 feet deep, constructed with 9⅝-inch casing, with 18 feet of Mott strainer. Water is delivered through a 7⅝-inch vertical discharge-

plants, those of Felix Martinez, W. N. French, and E. J. Hadlock, are located about 3 miles east of El Paso, Tex. The plants of J. A. Smith and J. S. Porcher are located in the valley of the Rio Grande about 8 miles east of El Paso, Tex. The pumping plants of Barker, Boyer, Burke, Carrera, Hager, Hines, Roualt, Totten, and the Agricultural College are located in the valley of the Rio Grande in the neighborhood of Las Cruces, N. Mex. The pumping plants of the Horaco Ranch Company are located near the post-office of Berino, N. Mex., which is situated 24 miles north of El Paso and 17 miles south of Las Cruces.

The fuel used in most of these pumping plants is gasoline, which term as here used includes the "distillate" manufactured from Texas crude oil, which is extensively used for fuel purposes. Its caloric value is somewhat less than that of the gasoline used in the Eastern States.

DETERMINATION OF VACUUM.

In all of the pumping plants except the one of E. J. Hadlock water was recovered by means of centrifugal pumps, which in nearly all cases were directly coupled to the top of the well casings. In order to determine the suction of the pumps, it was necessary to drill a hole in the goose neck of the centrifugal pumps and insert the vacuum gage. The measurements to determine the distance the pumps were required to lift the water were made from this vacuum-gage tap as datum in all cases. In column 6 is given the distance the pump is required to lift the water above the vacuum-gage tap. In column 7 the vacuum reading is given in feet of water. Therefore the total lift of the pump can be found in each case by adding the corresponding numbers in columns 6 and 7. In column 8 is given the distance that the natural level of the water in the well is lowered during pumping. If the vacuum gage had been placed at the exact level of the undisturbed ground water, the readings in column 8 would be identical with those in column 7. The numbers in column 8 are less than those in column 7, because in all cases the vacuum gage stood some distance above the natural level of the water in the well.

SPECIFIC CAPACITY.

The numbers in column 11 express the readiness with which the well furnishes water to the pump. The numbers in each case were found by dividing the numbers in column 10 by the corresponding numbers in column 8. These numbers therefore express the amount of water the well would furnish if the water level in the well was lowered but 1 foot. They constitute what is known as the "specific capacity" of the well, and are large in case of a good well and small in case of a poor well. (See Chapter VII.)

In column 12 there are given the same magnitudes as are expressed in column 11, reduced in each case to 1 square foot of well strainer.

Results of tests of pumping plants in the valley of the Rio Grande in New Mexico and Texas.

1. Name of plant.	2. Location.	3. Horse-power.	4. Fuel used.	5. Price of fuel.	6. Lift above vacuum.	7. Vacuum in feet of water.	8. Amount water is lowered.	9. Total lift.	10. Yield gallons minute.	11. Specific capacity.
					Feet.		*Feet.*	*Feet.*		*Gal. min.*
Felix Martinez	El Paso, Tex	10	Electricity	0.05	16.77	25.50	22.16	38.93	378	17.50
W. N. French	do	8	Gasoline	.14	12.65	18.05	13.35	30.70	269	20.20
E. J. Hadlock	do	5½	do	.14	5.20	22.60	13.03	27.80	258	19.80
J. A. Smith No. 1	do	28	Crude oil	.03	14.00	22.70	16.24	36.70	938	57.40
J. A. Smith No. 2	do	22	Gasoline	.14	15.45	26.10	21.00	41.45	1,325	63.20
J. S. Porcher	do	15	do	.14	12.80	23.07	20.59	35.87	658	32.00
F. C. Barker	Las Cruces, N. Mex	5	do	.17	20.18	25.40	22.48	45.58	131	5.83
E. M. Boyer	do	12	do	.17	17.60	22.70	19.76	40.30	658	33.30
F. Burke	Mesilla, N. Mex	21	do	.17	14.85	25.60	22.85	40.45	725	31.75
J. C. Carrera	Mesilla Park, N. Mex	8	do	.17	12.65	14.20	8.48	26.85	648	74.60
W. N. Hager	do	12	do	.17	17.17	17.60	15.20	34.77	325	22.30
A. L. Hines	Mesilla, N. Mex	8	do	.17	19.05	17.00	14.08	36.05	271	19.20
T. Roualt	Las Cruces, N. Mex	10	Wood	2.00	8.66	25.50	23.86	34.16	351	16.00
G. H. Totten	Mesilla, N. Mex	28	Gasoline	.17	16.95	26.40	22.50	43.35	464	20.60
Agricultural College	Mesilla Park, N. Mex	20	Wood	2.25	17.10	12.45	11.37	29.55	1,000	88.00
Horaco Ranch Company No. 1.	Berino, N. Mex	12	Gasoline	.17	9.71	14.18	13.75	23.89	837	60.80
Horaco Ranch Company No. 2.	do	12	do	.17	10.36	24.90	23.64	35.26	191	8.10
Horaco Ranch Company										

1. Name of plant.	2. Location.	12. Specific capacity per square foot strainer.	13. Cost of plant.	14. Interest and depreciation.	15. Labor and other cost.	16. Fuel cost per hour.	17. Fuel cost 1,000 foot-gallons.	18. Fuel cost per acre-foot.	19. Total cost per acre-foot.
		Gal. min.		*Per hour.*	*Per hour.*		*Cents.*		
Felix Martinez	El Paso, Tex	1.21	$1,200	$0.108	$0.050	$0.243	$\frac{1}{27}$	$3.43	$5.75
W. N. French	do	1.37	800	.072	.120	.112	$\frac{1}{14}$	2.26	6.13
E. J. Hadlock	do	.792	800	.072	.140	.074	$\frac{1}{58}$	1.58	6.02
J. A. Smith No. 1	do	1.01	3,000	.270	.150	.0975	$\frac{1}{171}$	.70	2.96
J. A. Smith No. 2	do	1.37	2,200	.198	.150	.35	$\frac{1}{91}$	1.43	2.79
J. S. Porcher	do	1.28	1,500	.135	.150	.21	$\frac{1}{67}$	1.73	4.10
F. C. Barker	Las Cruces, N. Mex	.337	1,200	.108	.120	.09	$\frac{1}{40}$	3.73	13.20
E. M. Boyer	do	1.969	1,200	.108	.150	.163	$\frac{1}{98}$	1.34	3.47
F. Burke	Mesilla, N. Mex	.734	2,100	.189	.150	.34	$\frac{1}{52}$	2.52	5.17
J. C. Carrera	Mesilla Park, N. Mex	3.530	900	.081	.120	.177	$\frac{1}{59}$	1.48	3.16
W. N. Hager	do	.760	1,200	.108	.150	.31	$\frac{1}{22}$	5.14	9.57
A. L. Hines	Mesilla, N. Mex	1.790	800	.072	.120	.255	$\frac{1}{23}$	5.10	8.95
T. Roualt	Las Cruces, N. Mex	.627	1,200	.108	.180	.223	$\frac{1}{32}$	3.47	7.91
G. H. Totten	Mesilla, N. Mex	.760	2,500	.225	.150	.37	$\frac{1}{33}$	4.34	7.91
Agricultural College	Mesilla Park, N. Mex	2.780	2,000	.180	.200	.52	$\frac{1}{34}$	2.83	4.88
Horaco Ranch Company No. 1.	Berino, N. Mex	1.690	992	.090	.090	.16	$\frac{1}{75}$	1.04	2.21
Horaco Ranch Company No. 2.	do	.178	992	.090	.090	.204	$\frac{1}{20}$	5.80	10.90
Horaco Ranch Company No. 3.	do	.892	992	.090	.090	.16	$\frac{1}{89}$	1.16	2.46

ation in the total value of the plant has been taken at 10 per
the rate of interest at 8 per cent. It is difficult to make ar
estimate of the amount of cost that should be charged up to
recovered by an irrigation plant, on account of the presence
unknown factors. If the plants were in operation every d
year it would be relatively easy to make an accurate estimat
factors in the operating expense. As it is, the plants are in
for a longer or shorter period, depending upon circumstanc
vary from year to year. Most of the plants are used mer
auxiliary to the supply of ditch water. In making the estim
charge for interest and depreciation it has been assumed that t
are in operation for two thousand hours each season. Th
sponds to a continuous twenty-four hours' daily use for thre
or two hundred days of ten hours each, and probably rep
fair average of the actual conditions.

In column 15 there is given a charge for labor and other
including oil, batteries, and such other incidental expenses
properly included under the head of depreciation. The ope
the gasoline plants can easily be put in charge of unskilled l
for the smaller plants full time is not required of such labor.

FUEL COST.

That part of the operating expenses which is properly char
fuel cost can be accurately determined. Column 16 expresse
for fuel per hour at the various plants. Column 18 expresse
per acre-foot of water recovered. In column 17 there is
cost of fuel for lifting 1,000 gallons of water through a di

COMMENTS ON THE RIO GRANDE PUMPING PLANTS.

The pumping plants of Martinez, French, Hadlock, Smith, and Porcher are all located in the bottom lands of the Rio Grande from 3 to 8 miles east of El Paso, Tex. From column 12 of the table it will be seen that the specific capacities of these wells per square foot of well strainer are nearly the same at the plants of Martinez, French, Smith No. 2, and Porcher, varying only between 1.21 gallons a minute at Martinez's well to 1.37 at French's well. These numbers, it should be remembered, give the amount of water furnished by each square foot of well strainer for 1 foot head of water. The numbers express, therefore, the degree of coarseness of the material in which the strainer is placed, provided, of course, that the well strainers themselves offer little or no resistance to the admission of water to the well. The specific capacity per square foot of strainer at the Smith plant No. 1 and the Hadlock plant is much smaller than the others. In the case of the Hadlock well there is no doubt but that this result is due to the fact that three of the Hadlock wells draw from surface water above a clay which overlies the sand and gravel from which the fourth well and the neighboring wells of Martinez and French draw their supply. In addition to this the strainers on these three wells of Hadlock consist of nothing but common pipe with drilled round holes. This poor form of strainer is sufficient in itself to cut down very materially the specific capacity of the wells.

The low specific capacity at Smith's plant No. 1 is probably due chiefly to a local deposit of fine-sized water-bearing sand. There is no covering layer of clay over the water-bearing sands and gravels at the location of these wells. The sands contain so little coarse material that fine sand is constantly being drawn into the wells by the pumps. This draft on the sand deposit at the east of the three wells at Smith's plant No. 1 is such that several wagon loads of gravel have been hauled from time to time and placed in the pit of the east well to replace the sand removed by the pumps.

The tests of the nine wells in the Rio Grande Valley near Las Cruces, N. Mex., form an interesting study. If we arrange them in order of their specific capacities per square foot of well strainer the list is as follows:

Specific capacity, per square foot of strainer, of nine wells in Rio Grande Valley near Las Cruces, N. Mex.

Name of well.	Gals. per min.	Name of well.	Gals. per min.
Carrera	3.530	Hager	0.760
Agricultural college	2.320	Totten	.760
Boyer	1.969	Roualt	.627
Hines	1.790	Barker	.337
Burke	.934		

In most cases this will mean the construction of additional wells, as the strainer surface can not be otherwise sufficiently increased. The necessity of keeping the lift of the pump down to a minimum is greatly emphasized in irrigation plants, and large strainer surface is the first requisite.

The efficiency of the smaller plants can also be increased by the construction of storage reservoirs or ponds for the accumulation of water before it is used for irrigation. In this way the duty of the water can be considerably increased. Barker's plant is the only one having such reservoirs. For plants that yield over a second-foot of water the reservoir is undoubtedly of little additional value.

The determination of the speeds of the centrifugal pumps at the various plants showed that in many cases the speed had not been properly adjusted. In all cases the speeds were too high. This was undoubtedly due to the fact that the vacuum had never been determined, so that the total lift of the pump was unknown.

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

OBSERVATIONS

ON THE

GROUND WATERS OF RIO GRANDE VALLEY

BY

CHARLES S. SLICHTER

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

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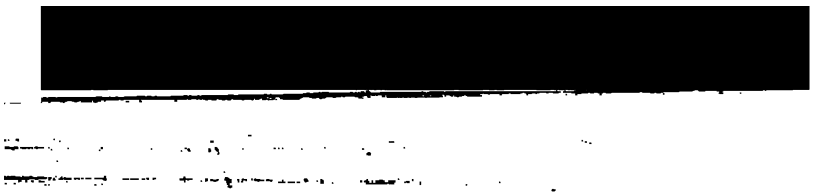

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
RECLAMATION SERVICE,
Washington, D. C., January 12, 1905.

SIR: I transmit herewith a manuscript by Prof. Chas. S. Slichter, entitled "Observations on the Ground Waters of Rio Grande Valley," and request that it be published as one of the series of Water-Supply and Irrigation Papers. This report contains results of recent investigations in connection with the underground-water problems of Rio Grande Valley, and it is believed that the facts made available will be of general interest and value.

Very respectfully,

F. H. NEWELL, *Chief Engineer.*

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

OBSERVATIONS ON THE GROUND WATERS OF RIO GRANDE VALLEY.

By CHARLES S. SLICHTER.

CHAPTER I.

INVESTIGATION OF THE UNDERFLOW AT THE NARROWS OF THE RIO GRANDE NEAR EL PASO, TEX.

An investigation of the underflow of the Rio Grande was begun in the latter part of August, 1904, at the narrows of the Rio Grande, a few miles above El Paso, Tex., where the stream flows through a narrow gorge of limestone. At this place is the site of the proposed Mexican-American international dam. At the surface of the water the distance between the walls of the gorge is less than 400 feet. The dam site has been investigated by the International (Water) Boundary Commission, organized by the joint action of the American and Mexican Governments, and maps and reports concerning the proposed dam will be found in the Proceedings of the International (Water) Boundary Commission, vol. 2, page 277.

A brief reconnaissance at the site of the proposed international dam indicated that there could be no underflow of any magnitude at this point. The distance between the walls of the gorge is less than 400 feet, and the test borings made by the Mexican commission in 1897 seemed to indicate that the maximum depth to bed rock is 86 feet. A cross section of the gorge, based upon the Mexican borings, is shown in fig. 2. In this diagram the vertical and horizontal scale are the same. A cross section of less than 40,000 square feet could not transmit a large volume of ground water even if other conditions were favorable. The highest velocity ever determined for ground water is about 100 feet in twenty-four hours, and assuming this maximum velocity at the above cross section, and a porosity of one-third in the water-bearing sands and gravel, the daily discharge would be 1,333,000 cubic feet, or 15½ cubic feet per second. The gradient of the water plane at the narrows is but $3\frac{8}{10}$ feet to the mile, and all other indications point to a low rather than a high velocity.

None of the usual indications of an underflow were found at this point. If there was a true underflow a stream undoubtedly wou'

flow perennially in the narrowest part of the gorge. Some miles above the site of the dam the valley broadens and is 2 to 5 miles in width, the sides gradually converging as the gorge is approached. The diminishing cross section would cause any underflow waters in the

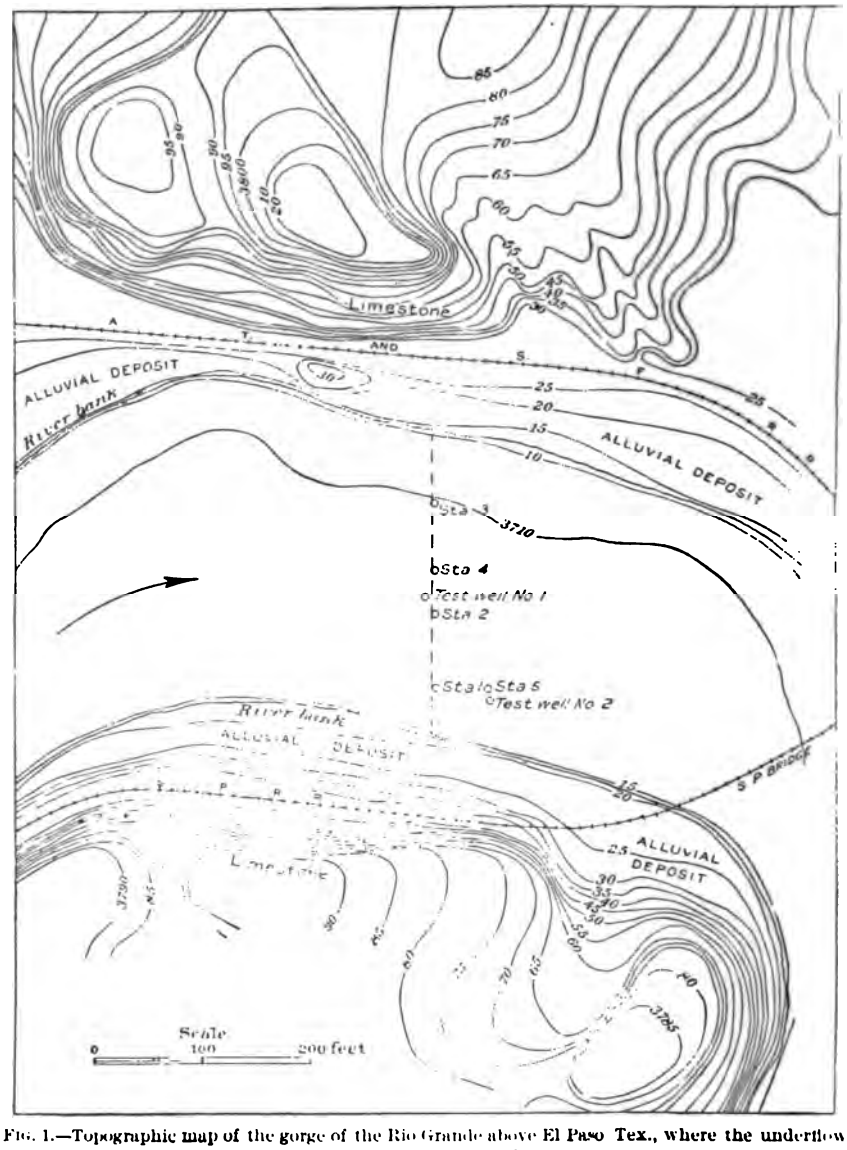
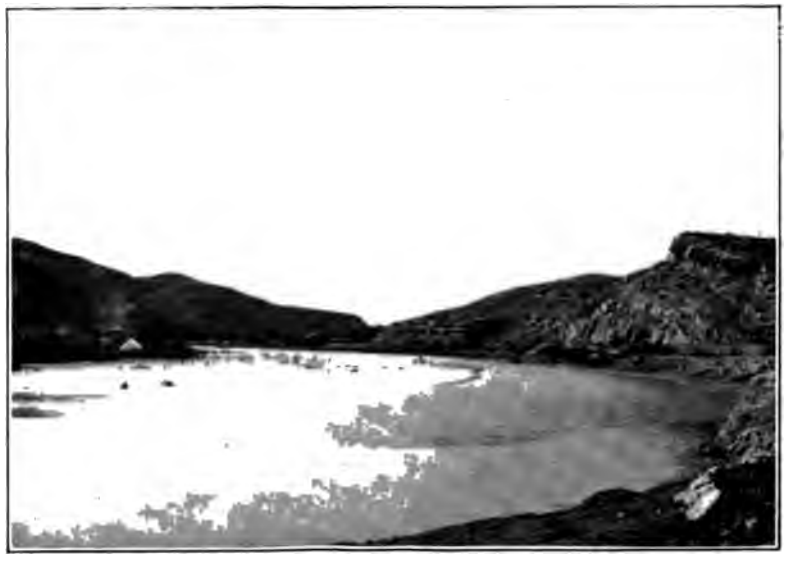


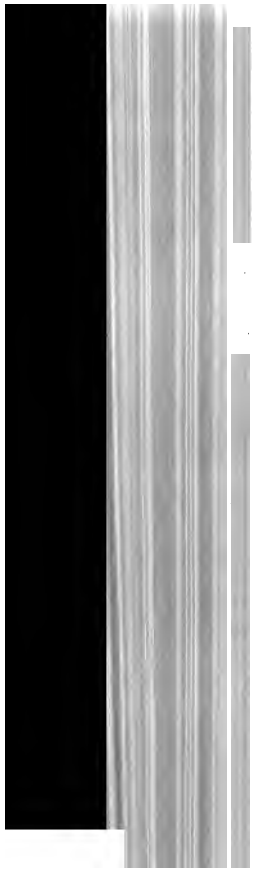
FIG. 1.—Topographic map of the gorge of the Rio Grande above El Paso Tex., where the underflow measurements were made.

valley above the narrows to seek relief at the surface in the narrow gorge and form a perennial flowing stream. Instead of this being the case the river is perfectly dry at the gorge when it ceases to flow above



A. GORGE OF THE RIO GRANDE ABOVE EL PASO, TEX.

B. WASHING DOWN TEST PIPE AT THE GORGE OF THE RIO GRANDE.



e pass. It was dry during several months of 1904. In addition to perennial surface flow through the narrowest portion of and above e gorge and near its converging sides, the ground waters should ve a slightly artesian character. None of these common indications an underflow were found.

Notwithstanding the above considerations, actual determinations of ıe rate of underflow were begun, largely on account of a local popu-ır belief that there is an enormous underflow at this point. The esults of the investigation are in accordance with general considera-ons above indicated.

The material in the river bed at the site of the proposed inter-ational dam consists of sand and fine gravel with occasional layers of ilt. No bowlders were encountered in sinking the test wells and the borings were made with great ease. The ground waters in the sands of the gorge were found to contain a large amount of dissolved solids.

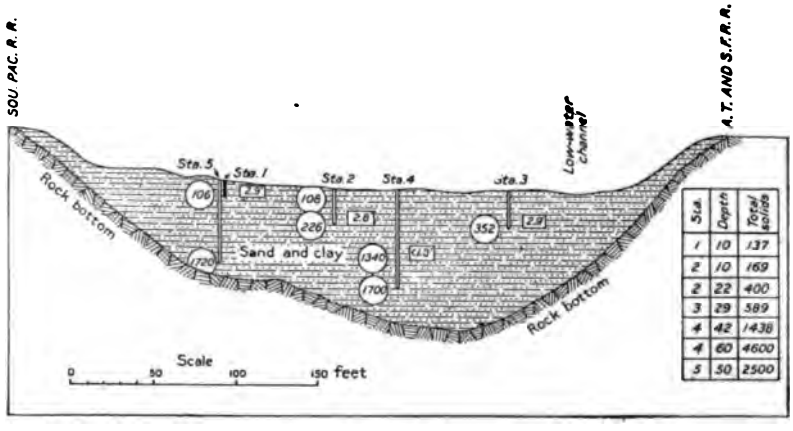


FIG. 2.—Cross section of the gorge of the Rio Grande, above El Paso, Tex., at the site of the proposed international dam.

The numbers inclosed in the rectangles give the velocity of the ground water in feet per twenty-four hours. The numbers inclosed in circles give the amount of common salt in parts per 100,000 dissolved in the ground water. The table at the right gives the depths of the test wells and the amount of total solids found in the water. The supposed rock bottom is given as determined by the Mexican borings, the vertical and horizontal scales being alike.

At a depth of 10 feet the waters contained about 100 parts per 100,000 of common salt, and the quantity became larger as distance from the surface increased. Below a depth of 32 feet so much salt was present that it was very difficult to determine the rate of motion of the ground waters. At a depth of 42 feet the common salt in solution amounted to 1,340 parts per 100,000; at 60 feet it reached 1,700 parts per 100,000; in a 50-foot test hole it amounted to 1,720 parts per 100,000. The total solids dissolved in the ground water were proportionately as large as the amount of common salt, so that at a depth of 40 feet the water was about half as strong as sea water, and at a depth of 60 feet it was

increase in total solids is not uniform, but becomes greater below the 35-foot line. The amount of chlorine shows a similar jump at about the same depth, but after increasing suddenly it seems to remain stationary. This may be due to the fact that the common salt in solution originates above the gorge, and has been slowly concentrated during a long time. The total solids, on the contrary, include the dissolved salts of lime, which can become almost indefinitely concentrated from the limestone débris in the gravels of the gorge itself.

It would be interesting to know whether the depth of the most sudden increase in the dissolved salts (say 35 feet) corresponds to the depth of the maximum scour of the river at the gorge.

The velocities of the ground water in the tests described above are undoubtedly the maximum velocities in the narrows of the gorge, since pains were taken to make the tests in the coarsest strata encountered in the borings. Layers of fine silt were frequently met with in putting down the test wells, which probably accounts for the stagnant condition of the water below the 35-foot level. These layers of silt are undoubtedly imbricated in such a way that movement of the deeper ground waters is impossible.

The total cross section in which the ground waters move is about 35 feet in depth and 325 feet in width and has an area of 11,200 square feet. If it is assumed that the porosity of the material is one-third and the maximum velocity of the ground water is 3 feet per day, the total discharge through the gorge does not exceed 11,200 cubic feet per twenty-four hours, or about 0.132 cubic foot per second, or about 50 gallons a minute. This amount of underflow is entirely insignificant. It is obvious that on account of the enormous quantity of dissolved solids the underflow would be worthless, no matter what its magnitude might be.

aring sand, however, is too fine grained to furnish wells of large pacity. The origin of ground water in this sand stratum is difficult

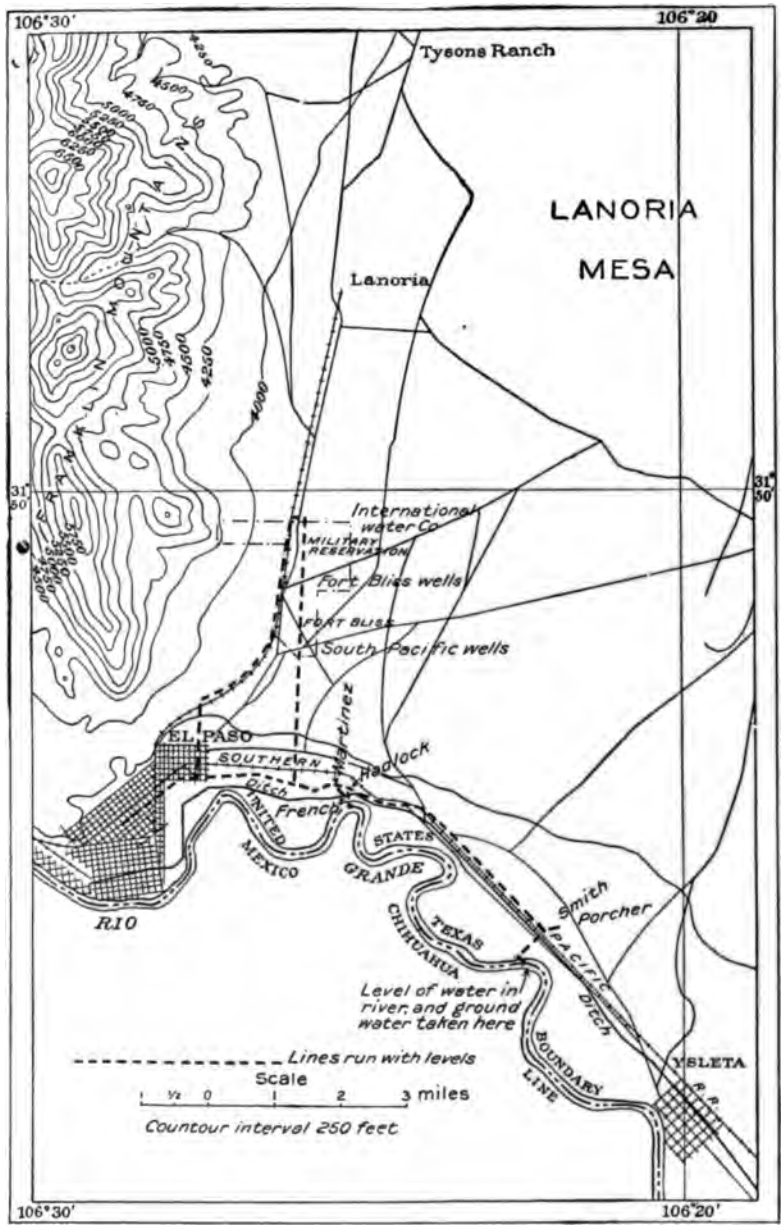


Fig. 4.—Map showing location of wells and pumping plants in the valley and on the mesa east of El Paso. The lines run with level are shown.

o trace. Nearly everywhere in the southern part of the mesa there s within a few feet of the surface from 3 to 6 feet of "caliche," a

cemented calcareous impervious conglomerate that prevents the
age of ground water. The deposit of "caliche" seems to be the r

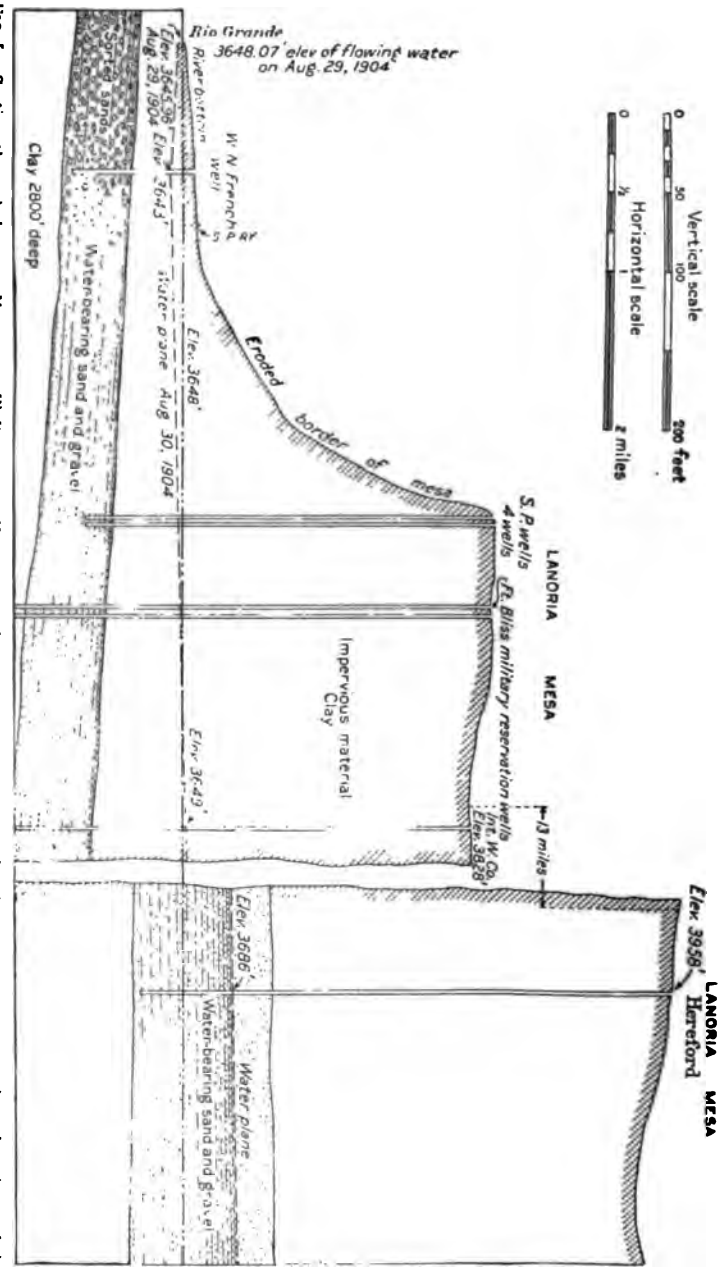
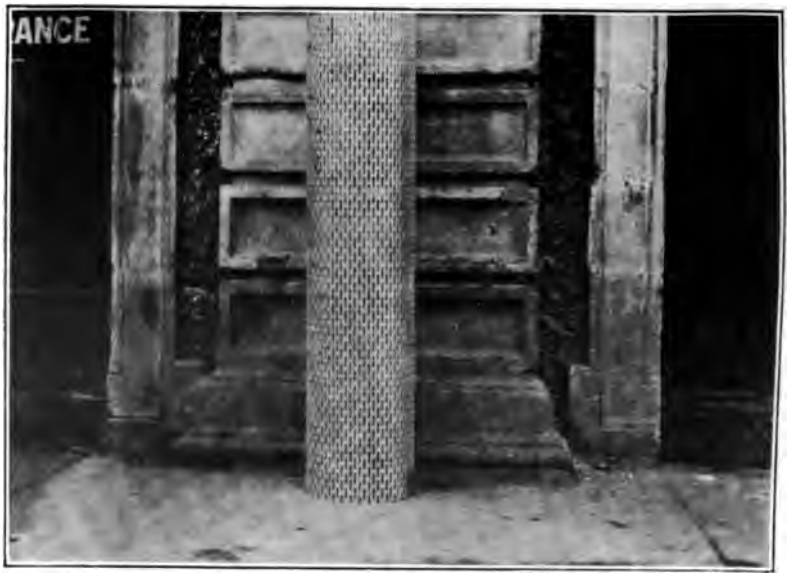


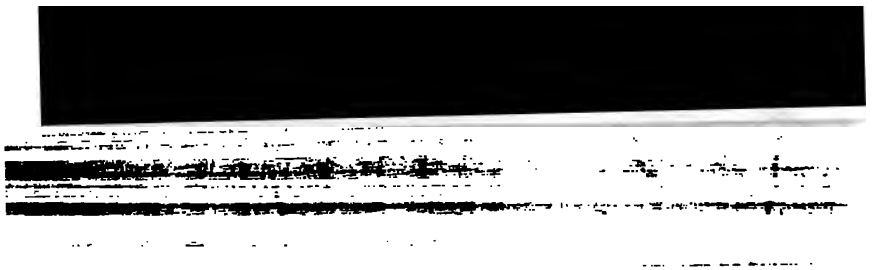
Fig. 5.—Section through Lanoria Mesa near El Paso, from Hereford to French's pumping plant, showing water-bearing sands and position of the water plane.

of the evaporation of the ground water near the surface of the m
Whenever this "caliche" is present the rainfall is undoubtedly un

A. CALIFORNIA WELL RIG.



B. PORCHER STRAINER.



enetrate the ground for a distance of more than a few feet. The ual precipitation is so slight, not exceeding a total of 9 inches, that portion that sinks into the ground must soon be evaporated by the nse heat of the sun wherever the "caliche" is present.

t is difficult to believe that the ground water in the stratum of sand erred to above is derived from the run-off from the north-south untain ranges. These mountain ranges consist very largely of nestone; and the small canyon streams run high in calcium, but the ters found in the sand stratum are very soft and show no indication having originated in a calcareous catchment area. The most probble source of the water of the sand stratum of the mesa is the rainll on the mesa itself, especially on limited portions located between and 25 miles north of the Rio Grande. Part of the surface material the mesa near Hereford is very sandy and is fairly well adapted to ceive and absorb a considerable part of the light rainfall. The railad wells drilled at this point indicate that only a fractional part of ne sand stratum is saturated with water, while in the lower part of ne mesa in the neighborhood of Fort Bliss, near the valley of the Rio rande, the water in the sand is found under an artesian head. These cts are brought out in fig. 5. As will be seen by inspection of this iagram, the source of the ground water found in the deep-lying sands nd gravels should be sought in the neighborhood of Hereford. The round water certainly can not have had its source near Fort Bliss, as is roved by its artesian character. North of Hereford a point is reached t which the ground waters are very strongly alkaline, and it is evient that water can not have originated so far north. The contrast etween the strong waters in the north and the soft waters in the outhern part of the mesa suggests that the waters of the one portion f the mesa must be cut off geologically from those of the other part.

Within a few miles of the southern edge of the mesa several deep ells have been sunk to obtain water from the above-mentioned sand nd gravel. Near the southern edge of the mesa the Southern Pacific ailroad has a group of wells designed to obtain ground water for ailroad purposes. The wells are 8 inches in diameter and about 270 eet deep, and each contains at the bottom a No. 6 Cook strainer, 7 nches by 20 feet in dimensions. The quality of the water is excelnt, but the quantity is very limited. The four wells, each supplied ith a Downey double-acting deep-well pump, are able to secure no nore than 150,000 gallons in twenty-four hours. About one-half nile north of the Southern Pacific wells two wells have been sunk to btain water for the use of Fort Bliss Military Reservation. The wo wells are about 20 feet apart, the depth of the eastern well eing 313 feet and that of the western 319 feet. The wells have a iameter of 8 inches, contain 6-inch suction pipes, and carry at the ottom a No. 6 Cook strainer, 5¼ inches in diameter and 8 feet long.

Paso, at the pumping plants of J. A. Smith and J. S. Porcher shows the slope of the water plane between the river channe

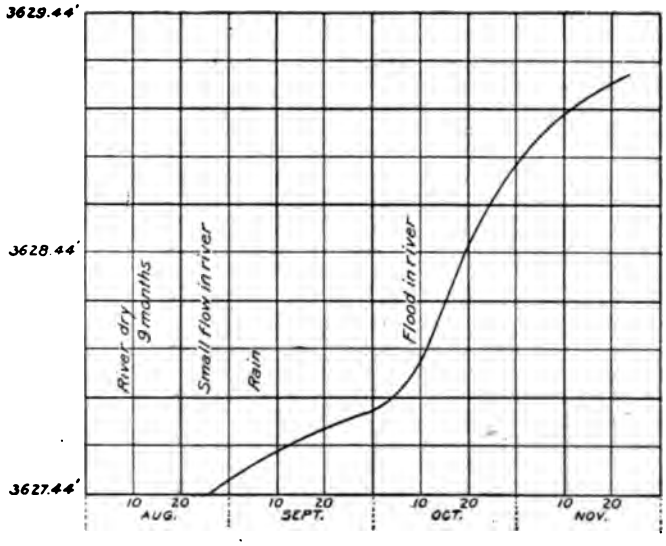
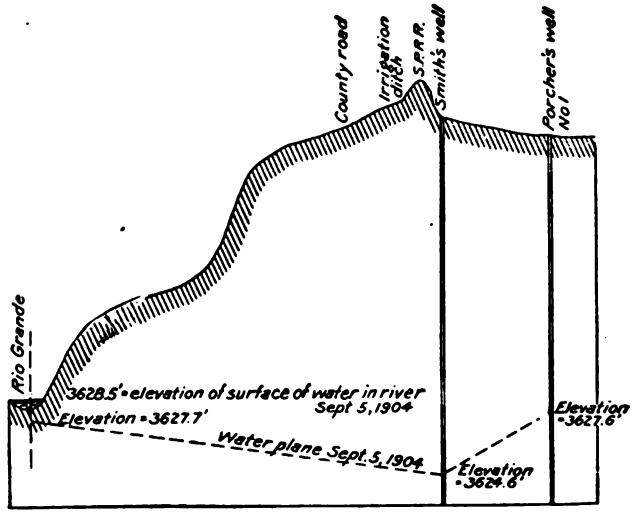


FIG. 6.—Elevation of water plane at Porcher's well No. 1.



Vater plane between Porcher's and Smith's pumping plants and the Rio Grande on Septen ber, 5, 1904.

ıe wells of Smith and Porcher, as determined on September 5

Partial analyses of samples of water from the Rio Grande Valley, Texas and New M

[In parts per 100,000.]

Name of well.	Depth of well.	Total solids.	Chlorine.	Hardness as $CaCO_3$.	Alkali as CaC
Samples taken near El Paso, Tex.:	*Feet.*				
City water, El Paso, Tex		127	54.0	70.4	
El Paso Brewery	58	72	21.4	30.0	
Felix Martinez	68	62	13.7	29.6	
E. J. Hadlock	30	104	31.5	47.7	
W. N. French	78	55	11.0	25.0	
J. S. Porcher	60	110	22.6	73.5	
J. A. Smith No. 1	62	174	55.6	67.0	
J. A. Smith No. 2	60	90	18.1	40.8	
Southern Pacific wells	270	42	2.13	11.1	
Fort Bliss Military Reservation	315	29	1.95	10.5	
El Paso and Northeastern at Fort Bliss	250 410	46	2.38	11.3	
International Water Co	260	22	1.48	7.25	
Samples taken near Berino, N. Mex.:					
Horaco Ranch Co. No. 2	53	126	30.9	45.8	
Horaco Ranch Co. No. 1	75	170	54.2	62.8	
Horaco Ranch Co. No. 3	62	203	63.9	59.5	
Samples taken near Las Cruces, N. Mex.:					
G. H. Totten	62	99	19.6	59.8	
T. Ronalt	48	76	11.2	47.3	
W. N. Hager	63	71	13.8	50.8	
A. L. Hines	59	73	10.8	47.5	
F. C. Barker	48	96	15.8	58.1	
Mrs. E. M. Boyer	52	57	7.5	38.6	
J. C. Carrera	58	83	11.2	54.2	
Samples taken at the gorge near El Paso:					
River water		128	9.6	55.8	
Station No. 2	10	169	63	95	
Do	22	400	137	100	
Station No. 3	29	589	213	139	
Test well No. 1	10	137	65.7	63.6	
Station No. 4	42	1,438	845	245.0	
Do	60	4,600	1,033	224	
Station No. 5	50	2,500	1,040	224	

A. SMALL RIG FOR DRILLING WELLS FOR STOCK.

B. TIMBER ON SACRAMENTO MOUNTAINS.

During nine months ending August 25, 1904, there was no water in river channel below El Paso. During this time the water plane the Porcher well No. 1 (an unused well 100 feet from the well of the w pumping plant) fell a total distance of 2 feet, or to an elevation 3,627.44 above mean sea level. By September 5, 1904, after four ys' rain the water in this well had risen 0.15 foot. The record of e week of rain is given in the table below. By October 2 the water ane had risen 0.37 foot (to 3,627.81. feet). On November 20, 1904, was within 0.3 foot of the elevation before the 2-foot loss noted ove, and was still rising at the rate of about one-fifth inch per 24 urs. On March 7, 1905, the water in the well had reached an elevaon of 3,630.79, or a total rise of 3.35 feet in seven months. There as water in the Rio Grande during all of this period.

These observations show clearly that the principal source of the ound water near Smith's and Porcher's ranches is seepage from e Rio Grande. A heavy flood about October 9 greatly accelerated e rate of rise of the water plane, as is shown by fig. 6, where the anges in level at Porcher's well No. 1 are represented by a curve.

infall, in inches, at El Paso, Tex., September 1 to 10, 1904, as reported by the United States Weather Bureau.

ptember 1	0.0	September 7	0.09
ptember 2	.09	September 8	Trace.
ptember 3	.53	September 9	Trace.
ptember 4	.62	September 10	.0
ptember 5	.16		
ptember 6	.61	Total	2.10

CHAPTER III.

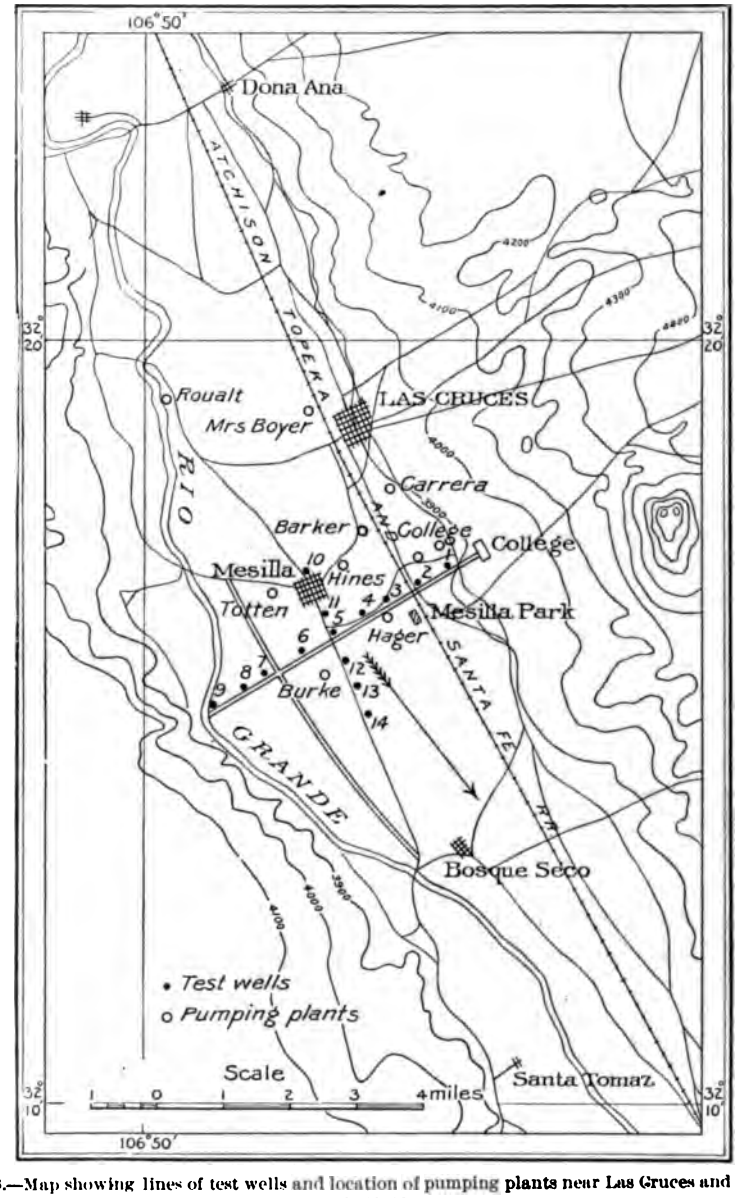
EXAMINATION OF GROUND-WATER SUPPLIES IN THE MESILLA VALLEY.

The valley of the Rio Grande begins to broaden north of the narrows in the neighborhood of El Paso, Tex. Near Las Cruces, N. Mex., the level bottom lands are about 5 miles wide, and irrigation has been extensively carried on for many years. Besides the city of Las Cruces, there are situated in this part of the valley the villages of Mesilla and Mesilla Park. Between old Fort Selden, north of Las Cruces, and the post-offices of Berino and Anthony, about 12,000 acres are under cultivation.

Owing to frequent shortage in the river supply of water, a number of pumping plants have been installed for the purpose of obtaining ground water for irrigation. One of the first wells for this purpose was drilled by the Agricultural College at Mesilla Park. At this place a coarse water-bearing gravel bed about 12 feet thick was found at a depth of 32 feet. This gravel is overlain by quicksand and adobe. The water level in the wells stood originally 16 feet below the surface of the ground. This well was used extensively for experimental purposes, and later a 12-inch well was put down to the same depth in the neighborhood of the 6-inch well. A great many tests of different kinds of pumps and engines were made at these wells, and a careful study was made of the cost of the recovery of the water, as well as of the amount of land in various kinds of crops that could be irrigated with the water recovered. A report on this work was published in 1903 by Professors Vernon and Lester and issued as a bulletin of the agricultural experiment station at Mesilla Park. As a result of the experiments and of the published reports on the wells at the agricultural station, a number of pumping plants have been installed during the present season, and many more are likely to be established in the near future. For that reason it has become important to have accurate information of the source of the ground-water supply in this part of the Rio Grande Valley and to determine the amount available for such use.

A reconnaissance near Las Cruces and Mesilla Park indicated that there is probably no underflow in this valley in the true sense in which that term is used. The rainfall upon the catchment area northeast of the valley is very slight and the run-off is correspondingly low. It

s not seem possible that the ground waters which are used for irri-ion could originate very largely in the rainfall upon the neighbor-g mesa and the foothills and upon the slopes of the Organ Mountains



. 8.—Map showing lines of test wells and location of pumping plants near Las Cruces and Mesilla Park, N. Mex.

the northeast. These mountains are very precipitous, and furnish all probability a very small amount of run-off to the ground waters the valley.

direction of the north-south line of test wells averaged 4.64 feet per mile at the time of the first observation on September 19, 1904. As shown on the lower part of fig. 9 the water plane, in an east-west direction, was nearly horizontal, but near the river it was somewhat higher than at the east end of the line of test wells, although the surface slopes gently in the opposite direction. A slight elevation in this section is seen at station 3. On an average the water plane in the east-west cross section slopes about 0.4 foot per mile toward the east end. It is evident from these cross sections that the ground water must flow in the general direction of the river valley. The direction of maximum slope of the water plane is shown in fig. 8 by the large arrow. This arrow should, therefore, indicate the direction of flow of the ground water. The gradient of the water plane of 4.64 feet per mile is very moderate, and it is probable that the real velocity of the ground water is low. The slight elevation at station 3 indicates that at this point the ground water comes to some extent from the north, and does not move from east to west. If such an east-west movement took place the motion would be uphill for the entire distance from station 1 to station 3.

SOURCE OF THE UNDERFLOW.

When the test wells were sunk it was expected that the position of the water plane in the wells would be observed every week until the time of high water in the Rio Grande, which would naturally be the spring of 1905. The test wells were sunk in cooperation with Prof. J. D. Tinsley, of the Agricultural College of New Mexico, who has made weekly observations of the height of the water plane in them. On October 5, 1904, heavy rains in the Rocky Mountains produced very disastrous floods in the Rio Grande and in nearly all the rivers heading in the Colorado Rocky Mountains. In the neighborhood of Las Cruces the maximum elevation of the river was higher than had been observed at any time in the last ten years. The period of very high water, so soon after the completion of the test wells, furnished an excellent opportunity of observing the effect of the floods in the Rio Grande upon the ground waters of the valley. Instead, therefore, of waiting for the spring floods of 1905, it became possible to determine immediately the essential facts in regard to the effect of the river upon the ground-water level. In Pl. IV the ground-water levels in the east-west line of test wells are given for each month from September 19 to March 26. The first observation taken on October 1 shows that the water had risen 0.4 foot since September 19. On October 9, however, the water at station 8 was 1.6 feet higher than on October 1. This was due to the flood of October 5. The flood raised the ground water at station 8 about 0.7 of a foot more during the next week, but from October 16 to 23 the small rise of 0.1 of a foot indicates that by October 23 the ground-water level at station 8 had tem-

porarily reached its highest position. Therefore, as a result of the flood, the gradient of the water plane immediately adjacent to the river, between stations 8 and 7, increased from 0.7 of a foot per mile to 2.3 feet per mile. The direction of movement of the water in the gravel was therefore undoubtedly downstream, even during times of flood, for while the east-west gradient increased to 2.3 feet to the mile in the immediate neighborhood of the river, the original downstream gradient of 4.64 feet to the mile was not materially affected. The test wells in the north-south line have not shown a departure of more than 0.1 of a foot from the original levels on September 19.

The table contains the observations on both sets of test wells until March 26, 1905. The Rio Grande had water in it continuously during this time. In high stages of the river the water in the wells still further rose, as is shown by the table and fig. 8. The total rise at station 8, located 0.4 mile from the river, was substantially 5 feet. The effect of the river can be traced at least 2 miles from its east bank. The rise at stations 1 and 2 during March, 1905, took place after irrigation had begun and is largely due to that cause.

Elevation of ground water, in feet, above datum,[a] in east-west line of test wells near Mesilla Park, N. Mex.

[Feet above datum.]

Date.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8
1904.								
September 19	22.60	23.03	23.45	23.19	22.57	23.14	23.85	23.8
October 1	22.61	23.10	23.43	23.15	22.85	23.19	23.16	24.2
October 9	22.74	23.21	23.50	23.15	22.85	23.19	23.38	25.8
October 16	22.77	23.23	23.48	23.13	22.86	23.14	23.59	26.1
October 23	22.77	23.23	23.46	23.13	22.83	23.12	23.73	26.2
October 30	22.77	23.21	23.42	23.13	22.86	23.07	23.81	26.2
November 6	22.74	23.18	23.36	23.08	22.84	23.08	23.94	26.3
November 13	22.77	23.20	23.36	23.09	22.86	23.10	24.05	26.3
November 20	22.76	23.16	23.32	23.06	22.83	23.10	24.13	26.3
November 27	22.77	23.18	23.34	23.03	22.83	23.11	24.18	26.4
December 18	22.69	23.08	23.27	23.00	22.84	23.22	24.41	26.5
1905.								
January 15	22.52	22.96	23.10	22.81	22.72	23.25	24.51	26.8
February 5	22.50	22.96	23.05	22.79	22.74	23.48	24.66	26.7
February 26	22.52	22.96	23.01	22.83	22.89	23.73	24.83	27.2
March 12	22.98	23.06	23.01	22.95	23.01	23.82	25.10	28.2
March 26	23.12	23.34	23.12	22.98	23.04	23.97	25.37	28.5

[a] Datum plane 3,800 feet above mean sea level.

U. S. GEOLOGICAL SURVEY

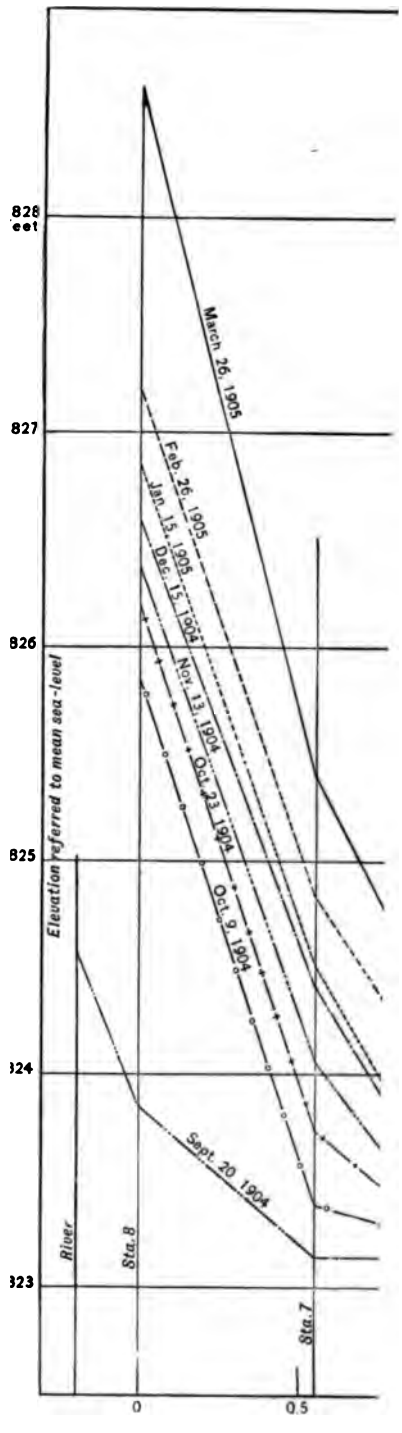


DIAGRAM SHOWING VARI.
TEST WEI

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The table contains the observations on both sets of test wells until March 26, 1905. The Rio Grande had water in it continuously during this time. In high stages of the river the water in the wells still further rose, as is shown by the table and fig. 8. The total rise at station 8, located 0.4 mile from the river, was substantially 5 feet. The effect of the river can be traced at least 2 miles from its east bank. The rise at stations 1 and 2 during March, 1905, took place after irrigation had begun and is largely due to that cause.

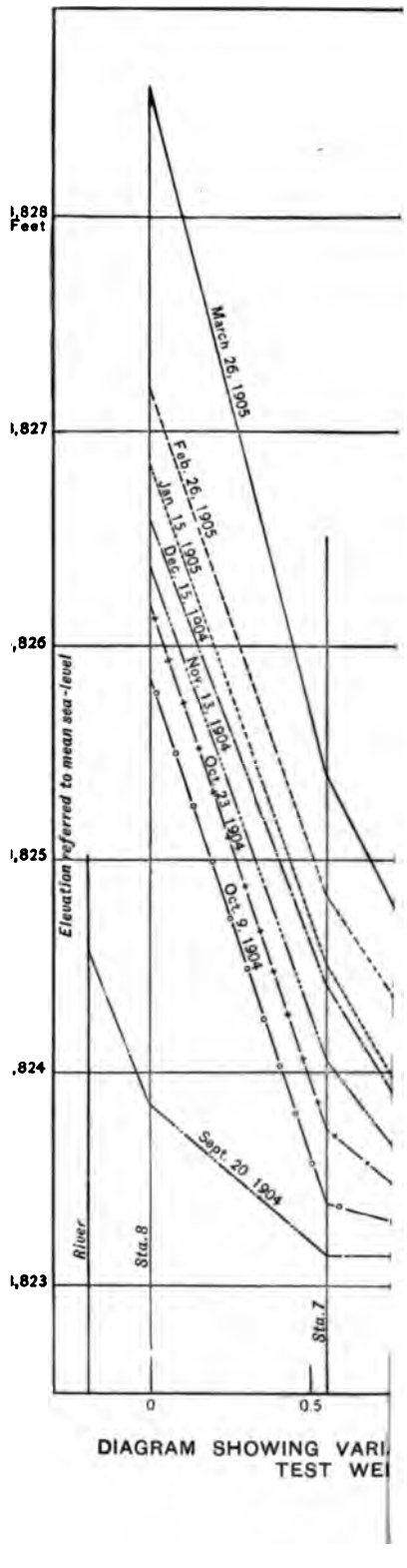
Elevation of ground water, in feet, above datum,[a] in east-west line of test wells near Mesilla Park, N. Mex.

[Feet above datum.]

Date.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.
1904.								
September 19	22.60	23.03	23.45	23.19	22.57	23.14	23.85	23.85
October 1	22.61	23.10	23.43	23.15	22.85	23.19	23.16	24.25
October 9	22.74	23.21	23.50	23.15	22.85	23.19	23.38	25.85
October 16	22.77	23.23	23.48	23.13	22.86	23.14	23.59	26.18
October 23	22.77	23.23	23.46	23.13	22.83	23.12	23.73	26.22
October 30	22.77	23.21	23.42	23.13	22.86	23.07	23.81	26.28
November 6	22.74	23.18	23.36	23.08	22.84	23.08	23.94	26.36
November 13	22.77	23.20	23.36	23.09	22.86	23.10	24.05	26.38
November 20	22.76	23.16	23.32	23.06	22.83	23.10	24.13	26.34
November 27	22.77	23.18	23.34	23.03	22.83	23.11	24.18	26.42
December 18	22.69	23.08	23.27	23.00	22.84	23.22	24.41	26.59
1905.								
January 15	22.52	22.96	23.10	22.81	22.72	23.25	24.51	26.85
February 5	22.50	22.96	23.05	22.79	22.74	23.48	24.66	26.78
February 26	22.52	22.96	23.01	22.83	22.89	23.73	24.83	27.20
March 12	22.98	23.06	23.01	22.95	23.01	23.82	25.10	28.20
March 26	23.12	23.34	23.12	22.98	23.04	23.97	25.37	28.59

[a] Datum plane 3,800 feet above mean sea level.

U. S. GEOLOGICAL SURVEY



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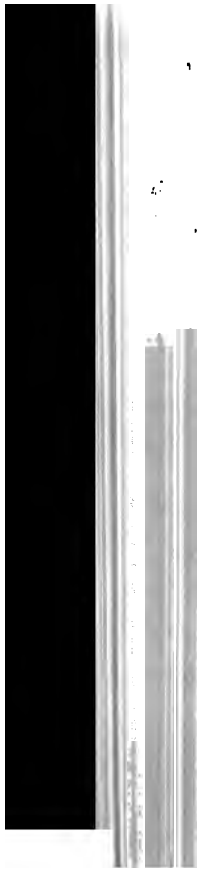


ration of ground water, in feet, above datum,[a] in north-south line of test wells near Mesilla Park, N. Mex.

[Feet above datum.]

Date.	No. 10.	No. 11.	No. 12.	No. 13.	No. 14.
1904.					
ptember 20	27.54	25.14	20.75	18.07	14.96
ctober 1	27.56	25.12	20.65	18.08	14.94
ctober 9	27.68	25.11	20.71	18.16	15.01
ctober 16	27.56	25.14	20.71	18.18	15.07
ctober 23	27.52	25.12	20.70	18.16	15.09
ctober 30	27.40	25.04	20.63	18.08	15.04
November 6	27.46	25.07	20.65	18.11	15.11
November 13	27.44	25.06	20.64	18.11	15.14
November 20	27.43	25.03	20.63	18.10	15.16
November 27	27.40	25.03	.....	.....	.....
December 18	27.40	25.03	20.64	18.14	15.29
1905.					
January 15	27.25	24.89	20.54	18.05	15.25
February 5	27.29	24.91	20.54	18.18	15.29
February 26	27.46	25.07	20.68	18.50	15.46
March 12	27.59	25.16	20.83	18.59	15.59
March 26	27.59	25.19	20.84	18.58	15.65

[a] Datum plane 3,800 feet above mean sea level.

The observations of the test wells show that the ground waters in the Mesilla Valley originate in the flood waters of the river. During times of low water the river bed is so thoroughly covered with mud that probably only a small amount of water escapes in the sand and gravels of the valley. During the period of flood, when the scour is deep, the contributions of the river to the underflow reach a maximum, as at that time the greatest amount of water is available for this purpose.

The observations of the ground-water level indicate also that a small portion of the underflow reaches the river valley from the mesa and foothills to the north and east of Las Cruces. The changes in the east-west line of water levels reached a maximum at the west end at station 8, with a secondary maximum at the east end at station 1. The high floods in the river were accompanied by rainfall on the mountains and mesa to the north and east of Las Cruces, and a sufficient amount of water penetrated the ground to cause the elevation of the water plane shown at the eastern end of the diagram. It will be observed that the total change in elevation at stations 1 and 2 was 0.2 of a foot. This change took place almost simultaneously with the rise at station 8.

Nevertheless, a slight indication of a lag in the rise of stations 1 and 2 can be observed from the diagram. The table on p. 26 gives the elevation of the water in the test wells as observed by Professor Tinsley between September 19, 1904, and March 26, 1905.

INDICATIONS OF THE AMOUNT OF GROUND WATER AVAILABLE.

The following table gives the rate at which water was contributed to the underflow at Mesilla Park by the river, and also by the rainfall on the foothills and mountains northeast of the river valley. The total amount contributed by the river during the thirty-three days comprised in the period of observation was 8,900,000 cubic feet of water for each linear mile of the river valley. Of this amount 5,120,000 cubic feet, or more than half, was contributed in eight days, between October 1 and 9, which include the flood beginning October 5. In column 4 of the table is given the rate at which 1 linear mile of the river channel furnished water to the underflow, expressed as a continuous flow in cubic feet of water per second. These same facts are expressed in gallons per minute in column 5. The average rate of contribution for the 33-day period was 3.03 cubic feet per second, or 1,360 gallons a minute. If a plant which pumped continuously 1,360 gallons a minute was installed for each mile of the river valley, all the water contributed by the river would be pumped, and the level of the ground water at the end of the period would be the same as at the beginning. Any greater rate of pumping would have a tendency to lower the water plane below its initial value and make a draft upon the permanent supply stored in the gravels.

In columns 6, 7, and 8 is given the amount contributed to the underflow by the rainfall upon the mesa, northeast of the valley. The total amount contributed during the thirty-three days covered by the table was 1,517,000 cubic feet of water per mile of valley—an average flow of 0.515 cubic foot per second, or 232 gallons a minute. During the last week covered by the table the gravels near the eastern edge of the valley lost water instead of gaining, and the entries in the table for this period are negative. A well pump drawing 232 gallons of water per minute, if operated continuously during the 33-day period, would just consume the seepage from the rainfall contributed by 1 linear mile of the valley.

Amount of water contribution to the underflow of the Rio Grande near Mesilla Park, N. Mex., between September 20 and October 23, 1904.

		Amount of ground water contributed by each mile of the river.			Amount of ground water contributed by rainfall upon mesa east of the valley per mile of river valley.		
1.	2.	3.	4.	5.	6.	7.	8.
Dates.	No. of days.	Cubic feet of water per 24 hours.	Cubic feet per second.	Gallons per minute.	Cubic feet of water per 24 hours.	Cubic feet per second.	Gallons per minute.
September 20 to October 1	11	110,500	1.28	575	40,500	0.47	211
October 1 to 9[a]	8	640,000	7.40	3,330	152,000	1.76	794
October 9 to 16	7	248,000	2.87	1,290	29,900	.35	155
October 16 to 23	7	117,200	1.36	745	5,950	.069	31
Total	33	[b]8,900,000			[b]1,517,000		
Average per day		270,000	3.03	1,360	45,800	.515	232

[a] Heavy flood on October 5, 1904.
[b] Total amount contributed for each mile of the valley in thirty-three days. Converting cubic feet into acre-feet we find that the river lost 204 acre-feet of water to the gravels of the underflow in thirty-three days, and 34.8 acre-feet were contributed by the rainfall in the same period. These amounts are for each mile of the valley.

NECESSITY FOR DEEP WELLS.

The examination of the underflow of the Mesilla Valley was confined exclusively to the zone of ground waters, in which are all of the irrigation wells of the valley. These wells have a depth of from 48 to 63 feet, and contain no more than 12 linear feet of strainer at the bottom. In some cases quicksand or silt was encountered at the bottom of the water-bearing gravels, but in other cases the drill was stopped while still in good material. There are no deep wells in the valley, but there is no indication that good gravels will not be met with at greater depths than those known at present. There seems to be a reasonable expectation of increasing enormously the specific capacities of the wells, and consequently the amount of ground water available for irrigation by drilling wells to greater depths. There is great need of an experimental well several hundred feet in depth that will test satisfactorily the ultimate possibilities of ground-water supply.

CHAPTER IV.

SUMMARY OF TESTS OF PUMPING PLANTS IN SOUTHERN NEW MEXICO AND TRANS-PECOS TEXAS.

The table on pp. 34–35 shows the results of tests of a number of pumping plants used for irrigation in the valley of the Rio Grande in southern New Mexico and trans-Pecos Texas. Most of the headings in the table explain themselves. Under the heading "Location" is given the post-office nearest to the ranch on which the pumping plant is located. The first three pumping plants, those of Felix Martinez, W. N. French, and E. J. Hadlock, are located about 3 miles east of El Paso, Tex. The plants of J. A. Smith and J. S. Porcher are situated in the valley of the Rio Grande about 8 miles east of El Paso, Tex. The plants of Barker, Boyer, Burke, Carrera, Hager, Hines, Roualt, Totten, and the Agricultural College are located in the valley of the Rio Grande in the neighborhood of Las Cruces, N. Mex. The pumping plants of the Horaco Ranch Company are located near the post-office of Berino, N. Mex., which is situated 24 miles north of El Paso and 17 miles south of Las Cruces.

The fuel used in most of these pumping plants is gasoline, which term as here used includes the "distillate" manufactured from Texas crude oil, which is extensively used for fuel purposes. Its calorific value is somewhat less than that of the gasoline used in the Eastern States.

DETERMINATION OF VACUUM.

In all of the plants, except the one of E. J. Hadlock, water is raised by means of centrifugal pumps, which are usually coupled directly to the top of the well casings. In order to determine the suction of the pumps it was necessary to drill a hole in the goose neck of the centrifugal pumps and insert the vacuum gage. The measurements to determine the distance the pumps were obliged to lift the water were made from this vacuum-gage tap as datum in all cases. In column 6 is given the distance the pump is required to lift the water above the vacuum-gage tap. In column 7 the vacuum reading is given in feet of water. The total lift of the pump can, therefore, be found in each case by adding the corresponding numbers in columns 6 and 7. In column 8 is given the distance that the water in the well is lowered during pumping. If the vacuum gage had been placed at the exact

season. This corresponds to a continuous use of three months of twenty-four hours daily, or two hundred days of ten hours each. It probably represents a fair average of the actual conditions.

In column 15 there is given a charge for labor and such other incidental expense—including oil and batteries—as is not properly included under the head of depreciation. The operation of the gasoline plants can be easily put in charge of unskilled labor, and for the smaller plants full time is not required of such labor.

FUEL COST.

That part of the operating expenses which is properly chargeable to fuel cost can be accurately determined. Column 16 expresses the cost for fuel per hour. Column 18 expresses the cost per acre-foot of water recovered. In column 17 are given the costs of fuel for lifting 1,000 gallons of water through a distance of 1 foot. For the purpose of comparison these results are expressed in fractional parts of a cent.

In column 5 is given the price of fuel. The price of gasoline is given in cents per gallon in barrel lots. The price of electricity is given in cents per kilowatt hour. Cost of wood at the ranch of T. Roualt is that of cottonwood per cord. The price of wood at the Agricultural College of $2.25 per cord is the rate for small Tornillo wood, which has a higher calorific value than the cottonwood used by Roualt.

Principal data derived from tests of Rio Grande pumping plants.

Name of plant.	Location.	Horsepower.	Fuel used.	Price of fuel.	Lift above vacuum.	Vacuum in feet of water.	Amount water is lowered.	Total lift.	Yield, gallons per minute.	Specific capacity.
1	2	3	4	5	6	7	8	9	10	11
					Feet.		*Feet.*	*Feet.*		*Gals. per min.*
Felix Martinez	El Paso, Tex	10	Electricity	$0.05	16.77	25.50	22.16	38.93	378	17.50
W. N. French	do	8	Gasoline	.14	12.65	18.05	13.35	30.70	269	20.20
E. J. Hadlock	do	5½	do	.14	5.20	22.60	13.03	27.80	258	19.80
J. A. Smith No. 1	do	28	Crude oil	.03	14.00	22.70	16.24	36.70	938	57.40
J. A. Smith No. 2	do	22	Gasoline	.14	15.45	26.10	21.00	41.45	1,325	63.20
J. S. Porcher	do	15	do	.14	12.80	23.07	20.59	35.87	658	32.00
F. C. Barker	Las Cruces, N. Mex	5	do	.17	20.18	25.40	22.48	45.58	131	5.83
Mrs. E. M. Boyer	do	12	do	.17	17.60	22.70	19.76	40.30	658	33.30
F. Burke	Mesilla, N. Mex	21	do	.17	14.85	25.60	22.85	40.45	725	31.75
J. C. Carrera	Mesilla Park, N. Mex	8	do	.17	12.65	14.20	8.48	26.85	648	74.60
W. N. Hager	do	12	do	.17	17.17	17.60	15.20	34.77	325	22.30
A. L. Hines	Mesilla, N. Mex	8	do	.17	19.05	17.00	14.08	36.05	271	19.20
T. Roualt	Las Cruces, N. Mex	10	Wood	2.00	8.66	25.50	23.86	34.16	351	16.00
G. H. Totten	Mesilla, N. Mex	28	Gasoline	.17	16.95	26.40	22.50	43.35	464	20.60
Agricultural College	Mesilla Park, N. Mex	20	Wood	2.25	17.10	12.45	11.37	29.55	1,000	88.00
Horaco Ranch Company No. 1.	Berino, N. Mex	12	Gasoline	.17	9.71	14.18	13.75	23.89	837	60.80
Horaco Ranch Company No. 2.	do	12	do	.17	10.36	24.90	23.64	35.26	191	8.10
Horaco Ranch Company No. 3	do	12	do	.17	11.56	20.80	18.55	32.36	750	40.40

Name of plant.	Location.	Horsepower.	Fuel used.	Specific capacity per square foot strainer.	Cost of plant.	Interest and depreciation.	Labor and other cost.	Fuel cost per hour.	Fuel cost 1,000 foot-gallons.	Fuel cost per acre-foot.	Total cost per acre-foot.
1	2	3	4	12	13	14	15	16	17	18	19
				Gals. per min.		*Per hour.*	*Per hour.*		*Cents.*		
Felix Martinez	El Paso, Tex	10	Electricity	1.21	$1,200	$0.108	$0.050	$0.243	1/27	$3.43	$5.75
W. N. French	do	8	Gasoline	1.37	800	.072	.120	.112	1/44	2.26	6.13
E. J. Hadlock	do	5½	do	.792	800	.072	.140	.074	1/58	1.58	6.02
J. A. Smith No. 1	do	28	Crude oil	1.01	3,000	.270	.180	.0975	1/171	.70	3.17
J. A. Smith No. 2	do	22	Gasoline	1.37	2,200	.198	.150	.35	1/91	1.43	2.79
J. S. Porcher	do	15	do	1.28	1,500	.135	.150	.21	1/67	1.73	4.10
F. C. Barker	Las Cruces, N. Mex	5	do	.337	1,200	.108	.120	.09	1/40	3.73	13.20
Mrs. E. M. Boyer	do	12	do	1.969	1,200	.108	.150	.163	1/98	1.34	3.47
F. Burke	Mesilla, N. Mex	21	do	.930	1,800	.162	.150	.34	1/52	2.52	4.87
J. C. Carrera	Mesilla Park, N. Mex	8	do	3.530	900	.081	.120	.177	1/59	1.48	3.16
W. N. Hager	do	12	do	.760	1,200	.108	.150	.31	1/22	5.14	9.57
A. L. Hines	Mesilla, N. Mex	8	do	1.790	800	.072	.120	.255	1/23	5.10	8.95
T. Roualt	Las Cruces, N. Mex	10	Wood	.62	1,200	.108	.180	.223	1/32	3.47	7.91
G. H. Totten	Mesilla, N. Mex	28	Gasoline	.760	2,000	.180	.150	.37	1/33	4.34	8.19
Agricultural College	Mesilla Park, N. Mex	20	Wood	2.32	1,600	.144	.200	.52	1/81	2.83	4.70
Horaco Ranch Company No. 1.	Berino, N. Mex	12	Gasoline	1.690	992	.090	.090	.16	1/75	1.04	2.21
Horaco Ranch Company No. 2.	do	12	do	.178	992	.090	.090	.204	1/20	5.80	10.90
Horaco Ranch Company No. 3.	do	12	do	.892	992	.090	.090	.16	1/89	1.16	2.46

COMMENTS ON THE RIO GRANDE PUMPING PLANTS

The pumping plants of Martinez, French, Hadlock, Smith, Porcher are all located in the bottom lands of the Rio Grande, 5 to 8 miles east of El Paso, Tex. Column 12 of the table shows the specific capacity per square foot of well strainer is nearly the s at the plants of Martinez, French, Smith No. 2, and Porcher, ran from between 1.21 gallons a minute at Martinez's well to 1.37 g at French's well. These numbers, it should be remembered, r sent the amount of water furnished by each square foot of well st for 1 foot head of water, and express, therefore, the degree of coars of the material in which the strainer is placed, provided, of cours the well strainers themselves offer little or no resistance to the admi of water to the well. The specific capacity per square foot of str at the Smith plant No. 1 and at the Hadlock plant is much sm than at the others. In the case of the Hadlock well, the low sp capacity is no doubt due to the fact that three of the Hadlock obtain water from above a clay which overlies the sand and gravel which the fourth well and the neighboring wells of Martinez and Fr draw their supply. Furthermore, the strainers on the three Ha wells consist of nothing but common pipe perforated with round h This poor form of strainer is sufficient in itself to cut down materially the specific capacity of the wells.

The low specific capacity at Smith's plant No. 1 is probably chiefly to a local deposit of fine-sized water-bearing sand. There covering layer of clay over the water-bearing sands and grav these wells. The sands contain so little coarse material that fine is constantly being drawn into the wells by the pumps. This dra the sand deposit at the easternmost of the three wells at Smith's No. 1 is so great that several wagon loads of gravel have been p in the pit of the east well to replace the sand removed by the pu

The tests of the 9 wells in Rio Grande Valley near Las Cr N. Mex., form an interesting study. The relative locations of 9 wells are shown in fig. 8. The rank of these wells in order of sp capacities per square foot of well strainer is as follows:

Specific capacity, in gallons per minute, of wells near Las Cruces, N. Mex., per squa of strainer.

	Gals. p
Carrera	
Agricultural College	
Mrs. Boyer	
Hines	
Burke	
Hager	
Totten	
Roualt	
Barker	

The first three of these wells are located near the eastern edge of the river valley, and their high specific capacity is undoubtedly due to coarse mountain débris that has been deposited along the eroded edge of the mesa. The high specific capacity at Hines's plant seems to be an exception to the general lower average prevailing in the intermediate district between the border of the mesa and the river channel, as at the plants of Hager, Totten, Burke, and Barker. The low specific capacity of the Barker well is due in part to its small diameter, and it is to be classed, therefore, with the Burke, Totten, and Hager wells rather than with the Roualt well. This last well is close to the river channel. Its low specific capacity is an indication of the progressive fineness of the deposits as the river is approached.

The specific capacities should be considered exceptionally high in the first wells in the above list, rather than exceptionally low in the others. Even the specific capacity of the Roualt well—over one-third of a gallon a minute per square foot of well strainer—would be regarded as high in many parts of the country.

The specific capacity of the three wells on the Horaco ranch near Berino, N. Mex., present an interesting study. These plants are located but a few hundred feet apart and are identical in all respects except in the depth of the wells. Nos. 2 and 3 are 9⅝ inches in diameter, and No. 1 is 7⅝ inches in diameter. Each has 18 linear feet of well strainer at the bottom, formed by drilling 1½-inch holes in the casing and wrapping the casing with No. 9 galvanized iron wire, leaving one-eighth inch space between. The enormous difference in the specific capacities of these wells is entirely due to the fact that No. 1 is 75 feet deep, No. 2 is 53 feet deep, and No. 3 is 62 feet deep. The small expense necessary to sink well No. 2 from a depth of 53 feet to a depth of 75 feet should change the cost of the water recovered from $10.90 per acre-foot to $2.21 per acre-foot.

Most of the pumping plants near Las Cruces have been very recently constructed, and changes will undoubtedly be made in many of them as the result of the experience of the present irrigation season. The wells at the Agricultural College were the first ones sunk in this part of the valley, and an excellent report on the tests of these wells, by Professors Vernon and Lester, was issued in April, 1903. The very high specific capacity of the college wells has influenced the construction of the other plants. With a few exceptions, it may be said that at the pumping plants in Mesilla Valley the engines and pumps are entirely too large for the wells, or the wells are too small for the pumps and engines. By comparing the high lifts recorded in column nine of the table with the amount of lowering of the water in the well, which is recorded in column eight, it will be seen that the lift of many of the plants can be considerably decreased by increasing the amount of strainer surface in the wells. In most cases this will make necessary

the sinking of additional wells, as the strainer surface can not be otherwise sufficiently increased. The necessity of keeping the lift of the pump down to a minimum is greatly emphasized in irrigation plants, and large strainer surface is the first requisite.

The efficiency of the smaller plants can also be increased by the construction of storage reservoirs or ponds for the accumulation of water before it is used for irrigation. In this way the duty of the water can be considerably increased. Barker's plant is the only one having such reservoirs. For plants that yield over a second-foot of water the reservoir is undoubtedly of little additional value.

The investigation showed that generally the speed of the centrifugal pumps had not been properly adjusted, and in nearly all cases was too high. This was undoubtedly due to the fact that the vacuum had never been determined, so that the total lift of the pumps was unknown. A table of observed and of correct speeds follows:

Sizes and speeds (in revolutions per minute) of centrifugal pumps used in the Rio Grande pumping plants.

Name of plant.	Kind of pump.	Actual speed.	Correct speed.
Martinez	Byron Jackson No. 5	1,028	565
French	Byron Jackson No. 4	938	890
Smith No. 1	Fairbanks Morse No. 6		
Smith No. 2	Byron Jackson No. 7	585	592
Porcher	Byron Jackson No. 5	712	629
Barker	Byron Jackson No. 3	1,110	1,244
Mrs. Boyer	Byron Jackson No. 5	730	665
Burke	Byron Jackson No. 6	733	585
Carrera	Byron Jackson No. 5	560	527
Hager	do	668	619
Hines	Rumsey No. 4	594	558
Roualt	Van Wie No. 3	525	
Totten	Byron Jackson No. 6	692	606
Horaco No. 1	Byron Jackson No. 5	695	513
Horaco No. 2	do	700	624
Horaco No. 3	do	692	598

CHAPTER V.

DETAILS OF TESTS OF PUMPING PLANTS.

The following pages contain detailed accounts with diagrams of the various pumping plants discussed in general terms in the preceding chapter of this report. The location of the various plants is marked in figs. 4 and 8.

PLANTS NEAR EL PASO, TEX.

PLANT OF E. J. HADLOCK.

The plant of E. J. Hadlock is located near the main country road near El Paso, Tex., about 400 feet east of the pumping plant of Felix Martinez. Water is pumped by a 5½-horsepower horizontal Otto gasoline engine geared to a horizontal double-acting piston pump. The wells consist of four 4-inch wells, arranged as shown in figs. 11 and 12. Three of the wells, Nos. 1, 2, and 3 in fig. 10, draw surface water from

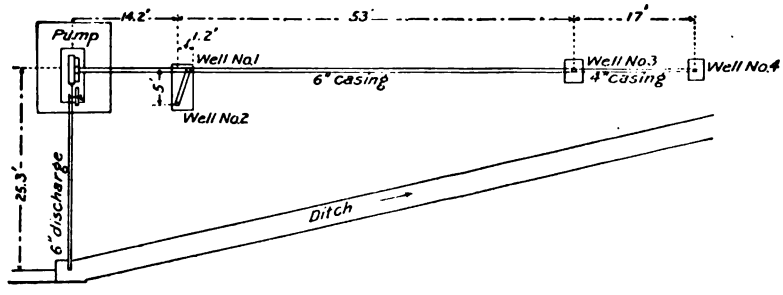


FIG. 11.—Plan showing arrangement of wells at Hadlock's pumping plant.

above a clay stratum. The fourth well, which is 54.35 feet deep and penetrates the surface water and clay, obtains very good water from a deposit of sand and gravel below the clay.

Wells Nos. 1, 2, and 3 are about 30 feet deep. Each of these has 6 feet of perforated iron pipe on the bottom, while well No. 4 has a 6-foot strainer constructed of perforated galvanized iron. During the test the engine made 210 revolutions and 81 explosions per minute. The pump made 69 strokes per minute. The vacuum gage attached to the suction pipe fluctuated very erratically, showing that the pump

months. The quantity of gasoline used was determined from the amount required to fill the tank to standard depth after one hour's run. As 2.1 quarts of gasoline were consumed per hour, the hourly cost for fuel, with gasoline at 14 cents per gallon, is $0.0735. The yield of water in one hour was 15,500 gallons, so that the fuel cost was $0.00475 per 1,000 gallons, $1.58 per acre-foot, and $0.000171, or one fifty-eighth of a cent per 1,000 foot-gallons (1,000 gallons raised one foot).

PLANT OF W. N. FRENCH.

At the pumping plant of W. N. French (see fig. 13) water is obtained from an 8-inch well, 66 feet deep, which has a 7-inch by 8-foot perforated galvanized iron strainer at the bottom. The water is raised by a No. 4 Byron Jackson horizontal-shaft centrifugal pump driven by a 10-horsepower Charter gasoline engine. The engine made 189 revolutions and 95 explosions a minute, no explosions being missed. The diameter of the driven pulley on the pump was 6 inches; that of the driving pulley on the engine was 30 inches. The speed of the pump was 938 revolutions a minute. The top of flange on the well casing is 12.65 feet below the top of the 5-inch discharge pipe, which rises from the pump at an angle of 45°. Before pumping, the water stood 4.7 feet below top of flange on the well casing. After one-half hour's pumping it was 18.05 feet below top of flange, showing that it was lowered 13.35 feet by pumping. The lift of the pump above the top flange of the well was 12.65 feet, making a total lift of 30.70 feet. The elevation of the water plane in the French well on August 29, 1904, was 3,642.969 feet; on September 8, after several days of rain, it was 3,643.07 feet. Between August 29 and September 8 it rained every day, and the neighboring pumping plant of Mr. Hadlock had not been in use. The elevation of the top of the delivery pipe at the French well was 3,658.884 feet.

The discharge was measured both by integrating with a Price acoustic current meter in a rectangular flume and by means of a fully contracted weir placed in the main ditch not far from the pumping plant. The cross section selected for the meter measurement had an average depth of 0.857 foot, an average width of 0.885 foot, and an area of 0.76 square foot. The average velocity of the water was 0.82 foot per second, giving a discharge of 0.596 second-foot, or 269 gallons, per minute.

The same discharge was also measured by a fully contracted weir. The length of the crest was 1.01 feet and the height of the water on the crest was 0.30 foot. The velocity of approach was about one-half foot per second. Using the weir formula,

$$q = c.\tfrac{2}{3}\sqrt{2g}\, b\,(\mathrm{H} + 1.4\mathrm{h})^{3/2}$$

and substituting the coefficient 0.608 for the number c in the formula (Table 23, Merriman's Hydraulics, 1903) we obtain,

$$q = 0.608 \times \tfrac{2}{3} \times 8.025 \times 1.01\ (3.06)^{3/2}$$
$$= 0.555 \text{ second-foot}$$
$$= 250 \text{ gallons per minute.}$$

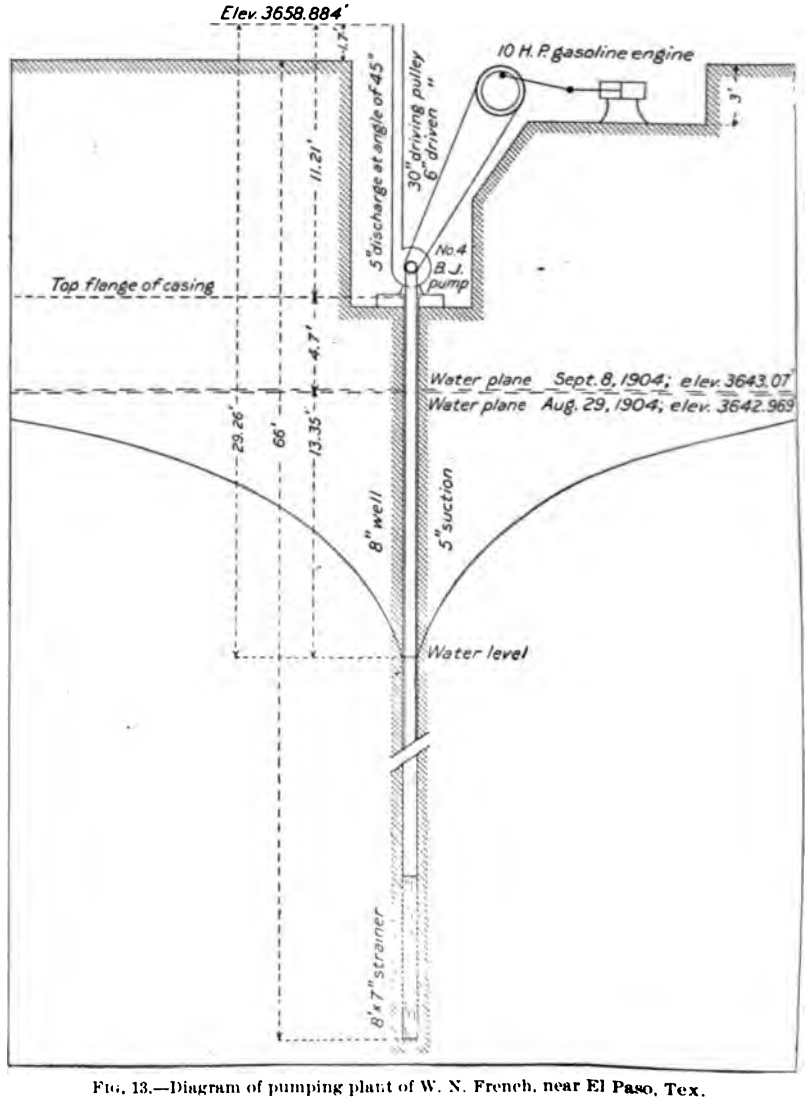


FIG. 13.—Diagram of pumping plant of W. N. French, near El Paso, Tex.

The discharge as determined by the current meter has been used in the following estimates:

The specific capacity of the well is 20.2 gallons a minute. As the strainer has an area of 14.7 square feet, the specific capacity for each square foot of strainer is 1.375 gallons per minute.

In the French test 8 gallons of gasoline were used in ten hours. With gasoline at 14 cents per gallon the cost of fuel is 11.2 cents per hour. As 16,150 gallons of water were obtained in one hour the fuel cost per 1,000 gallons was $0.00695, or $2.26 per acre-foot. The total lift being 30.7 feet the cost per 1,000 foot-gallons was $0.000226, or one forty-fourth of a cent.

PLANT OF FELIX MARTINEZ.

The plant of Felix Martinez is located about 3 miles east of the court-house of El Paso, Tex., near the main country road (see fig. 4). It consists of a No. 5 Byron Jackson horizontal-shaft centrifugal pump run by General Electric 10-horsepower direct-current motor, type C. E., class 4. The pump is located in a pit and is connected to a 6-inch well. The well is 68 feet deep and has 10 feet of perforated or slotted galvanized iron strainer at the bottom. The gravels, which were reached at a depth of 56 feet are fairly large, but contain a great quantity of fine sand. The pump is connected with the well by a 5-inch suction pipe and discharges through a vertical and horizontal 5-inch pipe into a rectangular flume. The discharge was measured by integrating with a Price acoustic current meter in the rectangular flume. The cross section of flume where measurements were taken had an average depth of 0.475 foot, an average width of 0.992 foot, and an area of 0.470 foot. The mean velocity was 1.78 feet per second, giving a total discharge of 0.838 cubic foot per second, or 378 gallons per minute.

The vacuum gage was attached to the goose neck of the centrifugal pump. After a few minutes pumping the vacuum was 18 inches, but it gradually fell to 24½ inches at the close of the first half hour, where it remained constant during the next hour. The vacuum, when corrected for altitude, is equivalent to 22.5 inches of mercury, or 25.5 feet of water.

On August 29, 1904, the elevation above sea level of the water plane was 3,643.13 feet; that of the vacuum-gage tap was 3,646.47 feet, and that of the top of discharge pipe was 3,659.90 feet. As the water level in the well was lowered 22.15 feet by pumping, the total lift was, therefore, 38.93 feet. The specific capacity of the well is 17.5 gallons per minute. As the area of the well strainer is 14.4 square feet, the specific capacity for each square foot of well screen was 1.21 gallons per minute.

The amount of electric current used during the pumping was determined by means of a Westinghouse watt meter. The current used in one hour's test (average speed of motor 1,485 revolutions a

minute) was 4,950 watts. Speed of the pump was 1,028 revolutions a minute. The diameters of the pulleys are as follows: Pulley on motor, 7½ inches; driven pulley on countershaft, 24 inches; driving pulley on countershaft, 14 inches; pulley on pump shaft, 6 inches.

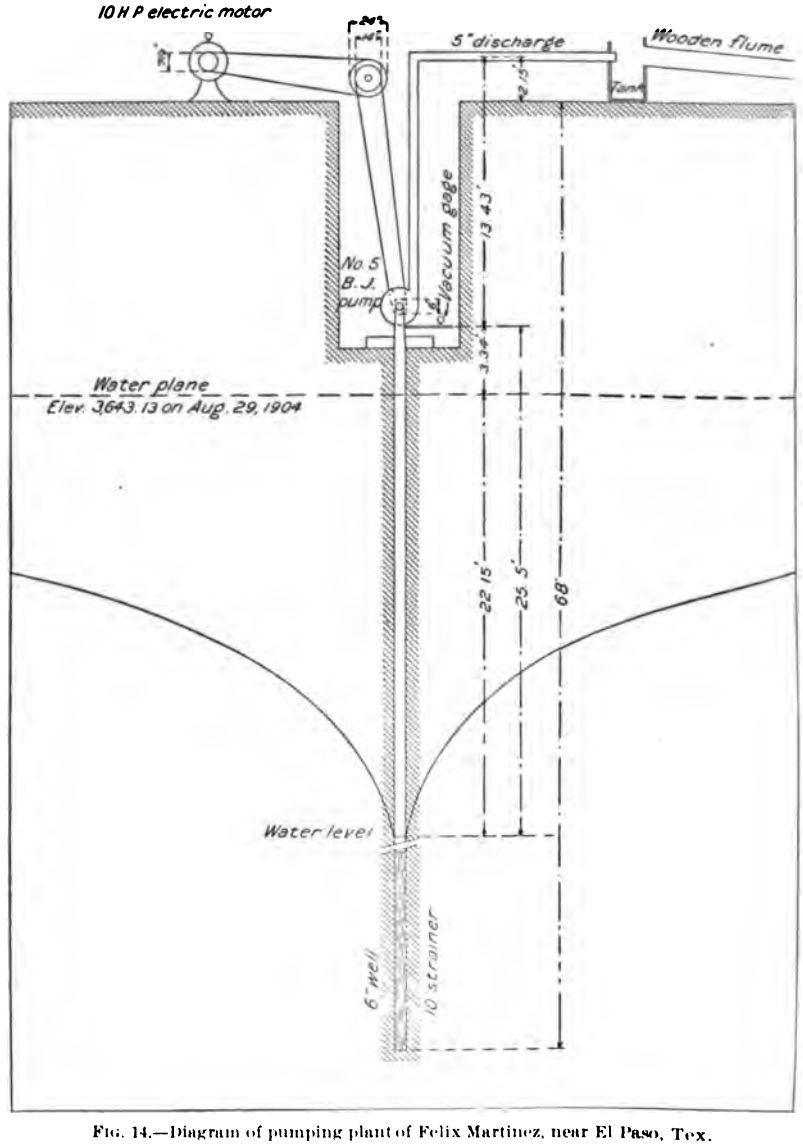


FIG. 14.—Diagram of pumping plant of Felix Martinez, near El Paso, Tex.

The power actually used at the plant is the equivalent of 4,950 watts, or 6.64 horsepower. The power represented by the discharge of 0.838 second-feet of water lifted 38.93 feet is equivalent to 2,030 foot-

ıds per second, which is equal to 3.7 effective horsepower. If applied horsepower, 6.64, is compared with the effective horse-er, 3.7, the total efficiency of the plant is found to be 55.5 per cent. duty of the plant can be found by comparing 4,950 watts, the trical energy consumed in one hour, with 655,200 foot-gallons, work done by the pump in one hour. The resulting duty is ,400 foot-gallons of water per kilowatt hour of electric current.

PLANTS OF J. A. SMITH.

The plants of J. A. Smith are located 8 miles east of El Paso, x., near the right of way of the Southern Pacific Railroad. There

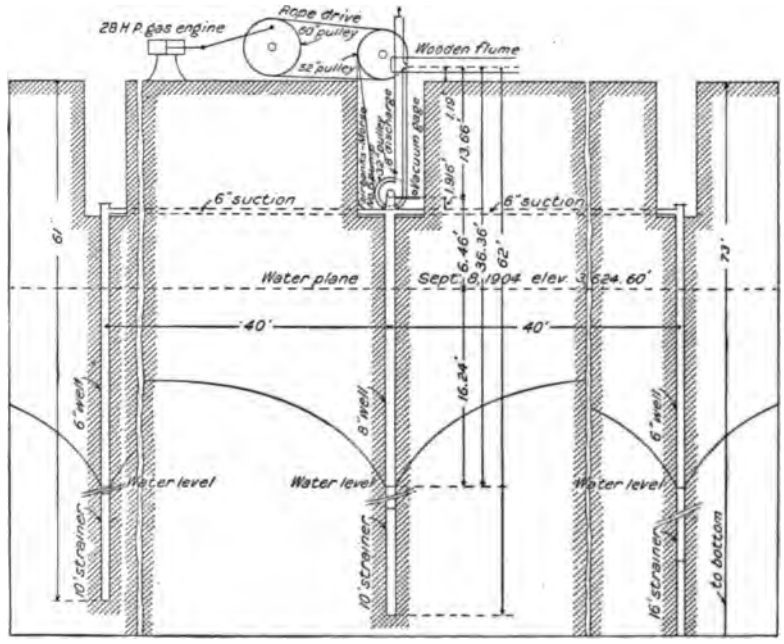


FIG. 15.—Diagram of J. A. Smith's pumping plant No. 1, near El Paso, Tex.

are two pumping plants on the same ranch. At the first or older plant there are three wells, 40 feet apart, in a row. The pump pit is over the middle well, which is 8 inches in diameter and 62 feet deep, measured from the surface. Fine sand and quicksand were passed through to a depth of 50 feet, then 12 feet of coarse gravel containing much fine material was encountered. A 10-foot slotted galvanized-iron strainer of the Porcher pattern was placed at the bottom of this well. The east well is 6 inches in diameter and 73 feet deep. The gravel at this point is 22 feet deep. A 16-foot Porcher strainer was used. The west well is 6 inches in diameter and 61 feet deep. The gravel was 11 feet deep, and a 10-foot Porcher strainer was used. All

Another experimental test of the plant was made when the engine was in charge of the regular help employed on the ranch. No effort was made to save oil or make a record, everything being managed exactly as it was during several months of pumping for irrigation. The test was for forty and one-half hours, extending over four consecutive days of about ten working hours each. The amount of crude oil used was 163.5 gallons, or 97 gallons per twenty-four hours, or 4.03 gallons per hour. This represents, therefore, the actual rate at which oil was consumed during the irrigation season. The cost of fuel is $2.90 per twenty-four hours, 12 cents per hour, ten forty-sixths of a cent per 1,000 gallons, and one one hundred and seventy-first of a cent per 1,000 foot-gallons.

The cost of the water at the same plant, when pumped with gasoline, was also determined. In a test of eleven hours' run with same engine, using gasoline instead of crude oil gas, 40 gallons of gasoline were consumed, or 3.64 gallons per hour. At 14 cents per gallon, the hourly cost for gasoline was $0.51. This makes the fuel cost of water $0.0092 per 1,000 gallons and $0.000236, or one forty-second of a cent per 1,000 foot-gallons.

The above estimates do not represent, of course, the total cost of pumping, as no items have been included to cover interest, depreciation, labor, etc.

The 934 gallons per minute furnished by the above plant amounts to a little over 2 second-feet, or 4 feet per twenty-four hours. The cost of fuel per acre-foot of water was, therefore, 70 cents when using crude oil and $2.95 when using gasoline costing 14 cents a gallon.

J. A. Smith's pumping plant No. 2 is about 1,000 feet north of plant No. 1, which is on the same ranch. There are two 8-inch wells, 40 feet apart, in an east-west line. Each one is 60 feet deep and is equipped with 12 feet of Porcher slotted galvanized iron strainer. The gravel bed is 12 feet thick and is overlain by a thick deposit of clay and hardpan. A No. 7 vertical shaft Byron Jackson centrifugal pump is connected to an 8-inch horizontal suction pipe that is 12.25 feet below surface. The pump is 7 feet from the east well and 33 feet from the west well. It was driven at a speed of 585 revolutions per minute by a 22-horsepower Fairbanks-Morse gasoline engine. The engine made 195 revolutions per minute, the engine being belted to the pump shaft from 36-inch driving pulley to 12-inch driven pulley. The vacuum shown at center of the suction pipe was 25 inches, or 23 inches of mercury when corrected for altitude, corresponding to 26.1 feet of water. The vacuum-gage tap is 14.85 feet below the top of the discharge pipe, above which the discharge jet rises 0.6 foot, so that the total lift is 41.45 feet. A vertical 10-inch pipe delivers the water into a nearly horizontal rectangular flume in which the discharge was meas-

ured by integrating with a Price acoustic current meter. The discharge was determined to be 2.945 second-feet, or 1,325 gallons, per minute. As the water in the wells was lowered 21 feet below the

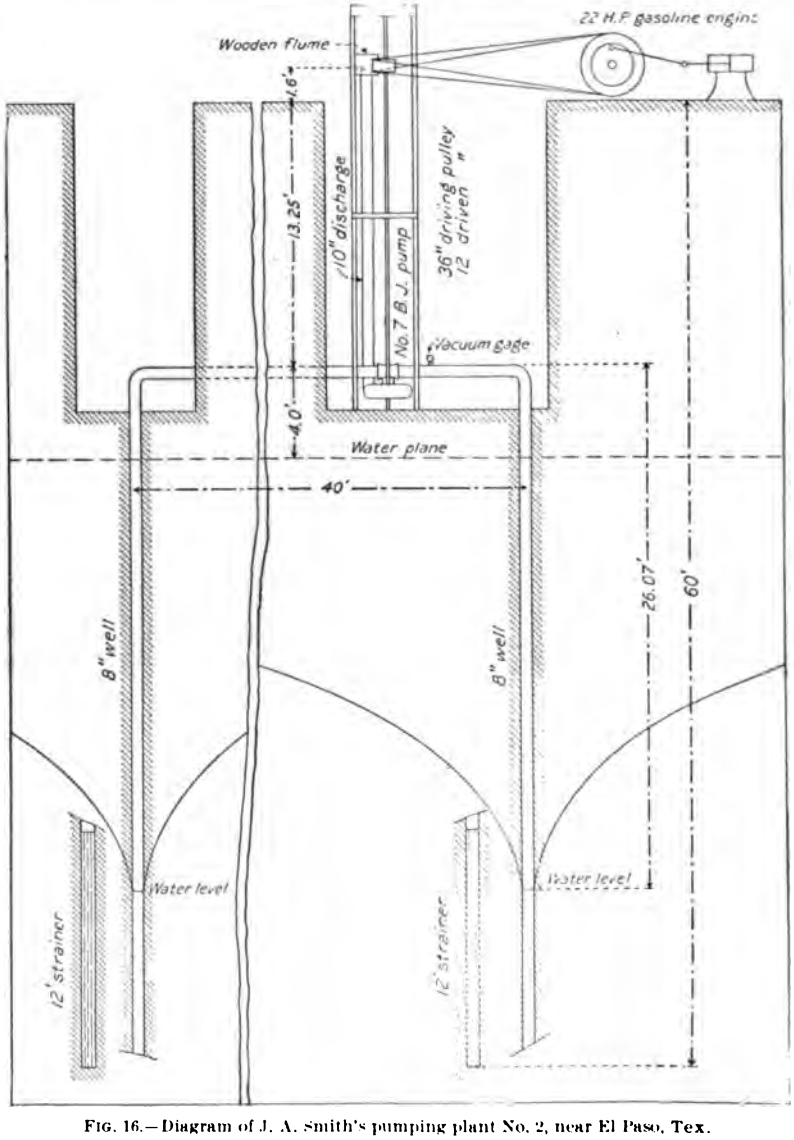


FIG. 16.—Diagram of J. A. Smith's pumping plant No. 2, near El Paso, Tex.

normal water plane by the pumps, the specific capacity of the two wells was 63.2 gallons per minute, or since the total strainer surface is 46 square feet, 1.37 gallons per minute for each square foot of strainer.

expense of pumping at this plant can readily be estimated as
he cost of fuel is concerned. The engine, as run in the above
nsumed per hour 2.5 gallons of gasoline or distillate, costing 14
er gallon. The fuel cost is, therefore, 35 cents per hour, 0.44
er 1,000 gallons, $0.000106, or one ninety-fourth of a cent, per
foot-gallons, and $1.43 per acre-foot.

PLANT OF J. S. PORCHER.

is pumping plant is located on the ranch of J. S. Porcher, in the
Grande Valley, about 8 miles east of El Paso, Tex., and about
feet east of J. A. Smith's first wells. Water is obtained from
ll 8¼ inches in diameter and 60 feet deep. The water-bearing
el has a thickness of 12½ feet and lies below a layer of quicksand.
re is a 12-foot slotted galvanized iron strainer at the bottom of the
. Mr. Porcher first used this type of strainer in the Rio Grande
ley. At the present time this form of strainer is universally used,
is known as the "Porcher" strainer (see Pl. II, *B*). Water is
ed by a No. 5 Byron Jackson horizontal-shaft centrifugal pump
ven by a 15-horsepower Columbus gasoline engine. The engine
de 212 revolutions and 75 explosions per minute. The diameter of
ving pulley was 30 inches and that of driven pulley 8 inches. The
mp made 712 revolutions per minute. The water is discharged
rough an 8-inch vertical pipe into a rectangular wooden flume. The
scharge from this rectangular flume was measured by integrating
ith a Price acoustic current meter. The selected cross section had
n average depth of 0.1792 foot, a width of 1.92 feet, and an area of
.344 square foot. The current meter showed that the average velocity
vas 4.245 feet per second, which gives a discharge of 1.46 second-feet,
or 658 gallons per minute. The vacuum gage read 22.4 inches, which,
when corrected for altitude, is equivalent to 20.4 inches of mercury,
or 23.07 feet of water. The elevation of the ground water at the well
on September 5, 1904, was 3,627.59 feet and that of the vacuum-gage
tap was 3,630.07 feet, so that the water in the well was lowered 20.59
feet by pumping. As the vacuum-gage tap is 12.8 feet below the top
of the discharge pipe the total lift is 35.87 feet.

Since the water level in the well was lowered 20.59 feet, the specific capacity of the well is estimated to be 32 gallons per minute, or 1.28 gallons per minute for each square foot of strainer.

The amount of gasoline used in running the engine was determined in two test runs. During the first test the consumption of gasoline from 6 a. m. to 4 p. m. was ascertained by measurements in the gasoline reservoir. In the ten hours' test there was used 14.3 gallons, or 1.43 gallons per hour. In the second test Mr. Porcher determined the time necessary to consume 5 gallons of gasoline in the engine. At 6.30 a. m. on the day of the test 5 gallons of gasoline were placed in the empty

gasoline reservoir. All the gasoline had been used up by 10.20 a. m. so that the consumption was 5 gallons in 3.83 hours, or 1.31 gallon per hour. As the engine was run with considerable care during thes

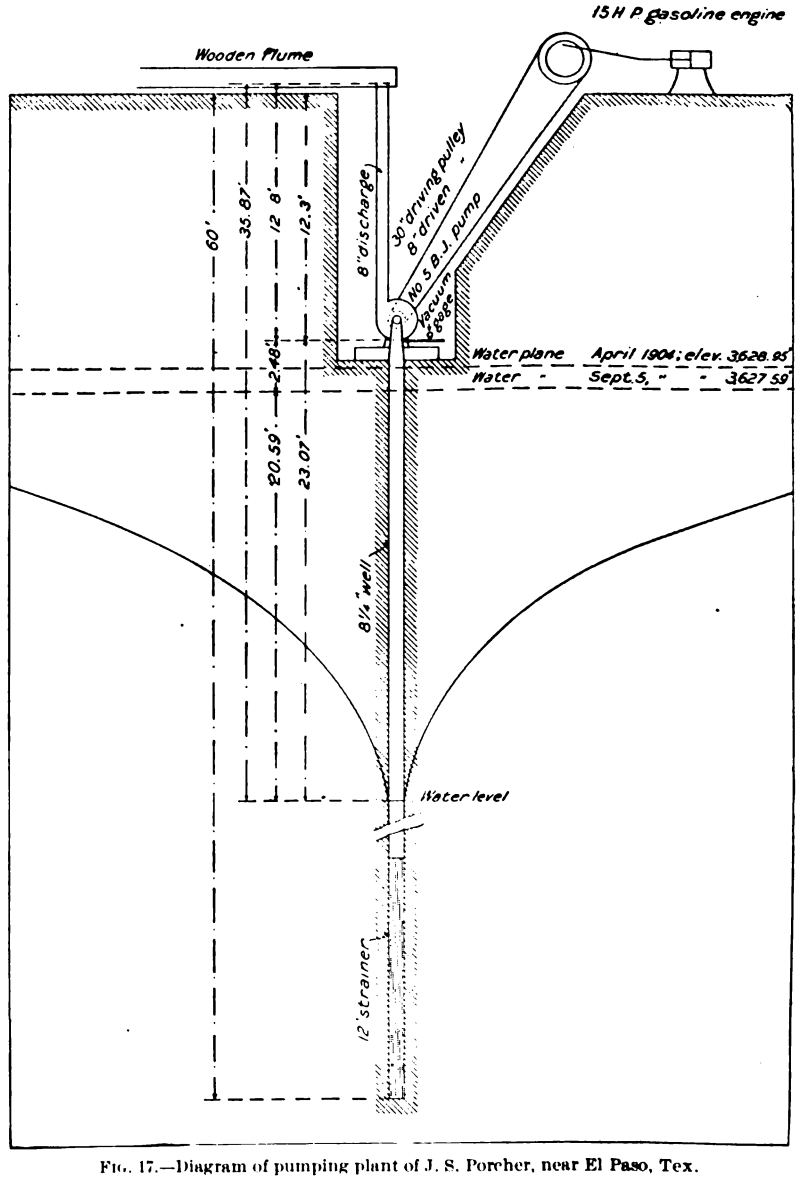


FIG. 17.—Diagram of pumping plant of J. S. Porcher, near El Paso, Tex.

tests, it is probable that the consumption of gasoline normally runs as high as 15 gallons for ten hours. The hourly cost for fuel, with gasoline at 14 cents per gallon, was 21 cents. As 39,500 gallons of water

were obtained in one hour, the cost was $0.00531 per 1,000 gallons, $1.73 per acre-foot, and $0.0001, or one sixty-seventh of a cent, per 1,000 foot-gallons.

A 4½-acre field of alfalfa can be irrigated with the pump in from fourteen to nineteen hours. After a rain it was irrigated in fourteen hours, but sixteen hours usually are required. A number of irrigations of the same field have varied from sixteen to eighteen hours each. This field was irrigated every seven days, and the crop taken off at the end of the fourth week, so there were three irrigations to a crop.

With gasoline, or distillate, at 14 cents per gallon, or $2.36 per acre, per crop of alfalfa (three irrigations), the crop cut from the field averaged fully a ton to an acre, and at the selling price of $12 to $14 per ton, the irrigation with the pump could be carried on at a good profit. If the selling price had been as low as $7 per ton there would be no profit in the irrigation of alfalfa by pumping.

TESTS OF PUMPING PLANTS IN MESILLA VALLEY, NEW MEXICO.

PLANT OF F. C. BARKER.

This plant is located on the ranch of Mr. F. C. Barker, about 1 mile south of Las Cruces, N. Mex. The pumping plant is used to irrigate about 20 acres of garden truck. Water is obtained from a 6-inch well, 48 feet deep, containing 12 feet of slotted galvanized-iron strainer at the bottom. The water is raised by a No. 3 Byron Jackson horizontal-shaft centrifugal pump, driven by a 5-horsepower Otto gasoline engine. The engine is belted directly to the pump from a 20-inch driving pulley to a 6-inch driven pulley. The engine made 334 revolutions and from 92 to 97 explosions per minute. The speed of the pump was 1,110 revolutions per minute.

The vacuum-gage tap was 2.92 feet above the water plane in September, 1904, and 17.73 feet below the center of 3-inch horizontal discharge pipe. The lift of the pump above the vacuum-gage tap when discharging into the first of two irrigation reservoirs is 17.73 feet.

The lift above the vacuum-gage tap when discharging into the second irrigation reservoir was 20.18 feet. The vacuum gage read 24.50, which, when corrected for altitude, is equivalent to 22.50 inches of mercury, or 25.4 feet of water. This makes the total lift when filling the second reservoir 45.58 feet.

The discharge of the pump was ascertained by determining, by means of a stop watch, the time required to fill a tank holding 47.6 gallons. As the tank was filled in 21.8 seconds, the discharge of the pump is 0.291 second-foot, or 131 gallons per minute. As the water level in the well is lowered 22.48 feet during pumping, the specific capacity of the well must be 5.83 gallon per minute, or 0.337 gallons per minute for each square foot of strainer.

This pumping plant is unusually well constructed. The machinery is well housed, and there are two concrete-lined reservoirs for storing

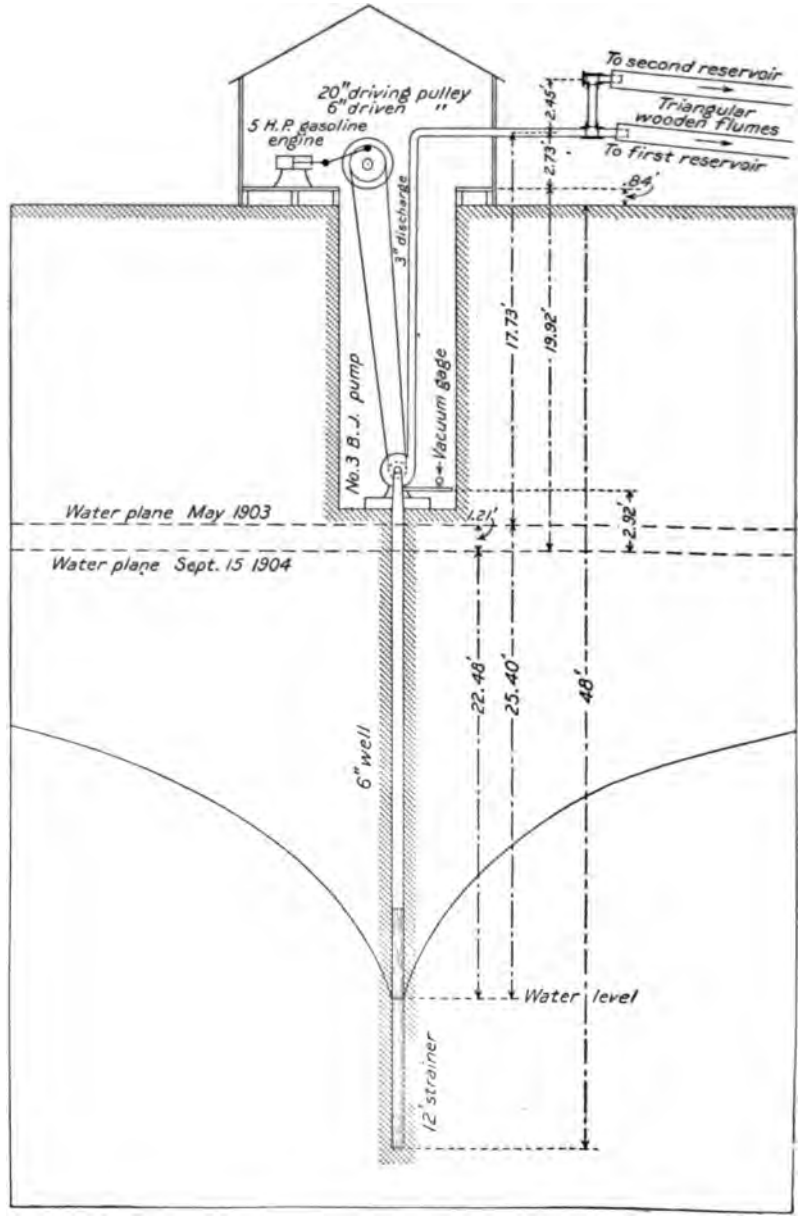


FIG. 18.—Diagram of pumping plant of F. C. Barker, near Las Cruces, N. Mex.

water for irrigation. It takes the pump eight hours to fill a reservoir, which is emptied in about an hour's irrigation. The cost of the plant complete was $1,200.

ıe amount of gasoline used was not accurately determined, but it lly exceeded one-half gallon per hour when the engine was develop- about its full horsepower. With gasoline at 17 cents a gallon, the cost may safely be put at 9 cents an hour. On this basis the fuel of water was $0.0115 per 1,000 gallons, $3.73 per acre-foot, and .00252, or one-fortieth of a cent per 1,000 foot-gallons.

PLANT OF J. C. CARRERA.

This plant is located on the ranch of J. C. Carrera, about half way tween Las Cruces and Mesilla Park, N. Mex., near the east or upper ghway between the Agricultural College and Las Cruces. The well 6 inches in diameter and 58 feet deep, and is equipped with a slotted alvanized-iron strainer 5½ inches in diameter by 15 feet long. The ater is recovered by a No. 5 Byron Jackson horizontal-shaft centrifgal pump, driven by an 8-horsepower Fairbanks-Morse gasoline ngine. The engine ran at a speed of 234 revolutions a minute, missng no explosions. The pump was driven at a speed of 560 revolutions a minute by direct belting to engine from 20-inch driving pulley to 3-inch driven pulley.

The vacuum-gage tap was 12.65 feet below the center of the 5⅝-inch horizontal discharge pipe and 5.72 feet above the water, which, when the well was first dug, three years before the test, was 2.7 feet higher than at present. The vacuum gage read 14.5 inches, which gives, after correction for altitude, 12.5 inches of mercury or 14.2 feet of water. The total lift was therefore 26.85 feet. The discharge of the pump was 1.44 second-feet or 648 gallons a minute. The water in the well was lowered only 8.48 feet, so that the specific capacity of the well is 76.4 gallons per minute, or 3.53 gallons per minute for each square foot of well strainer.

Twelve gallons of gasoline were used for eleven hours' run, including the amount consumed by igniting torch. With gasoline at 17 cents per gallon, the fuel cost of water is 17¾ cents an hour, 0.456 cents per 1,000 gallons, $1.48 per acre-foot, and $0.017 or one fifty-ninth of a cent per 1,000 foot-gallons.

PLANT OF FRANK BURKE NEAR MESILLA, N. MEX.

This plant is located on the ranch of Frank Burke, about one-half of a mile south of Mesilla Park, N. Mex. Water is obtained from a 12-inch well, 52 feet deep, containing 11½ feet of slotted galvanized-iron strainer at the bottom. The well passes through 8 feet of soil and sand, 14 feet of quicksand with small pebbles, and 38 feet of sand and gravel of maximum size 3 inches. The water is recovered by a No. 6 Byron Jackson horizontal-shaft centrifugal pump, driven by a 21- horsepower Otto gasoline engine. The engine is belted to a pu

shaft from 40-inch driving pulley on engine, thence to a 20-inch driven pulley on countershaft, thence from 16-inch driving pulley on countershaft to 10-inch driven pulley on pump shaft. The speed of pump

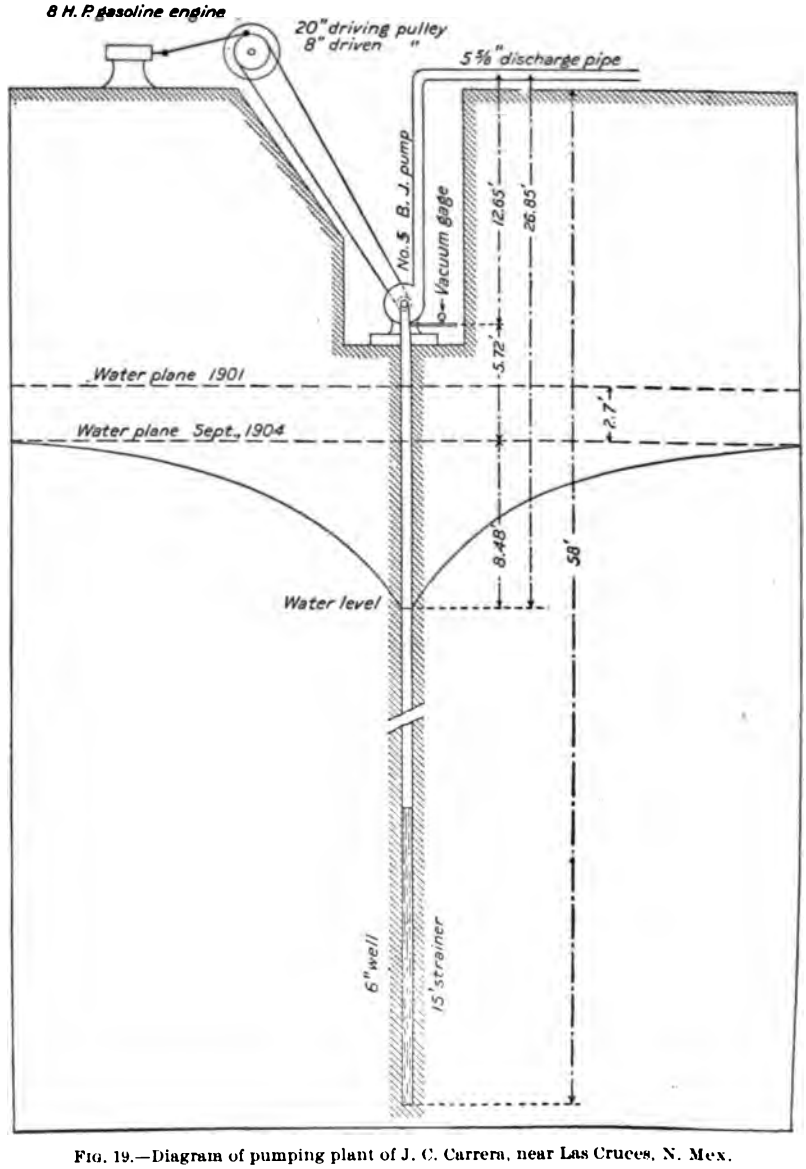


FIG. 19.—Diagram of pumping plant of J. C. Carrera, near Las Cruces, N. Mex.

during the test was 733 revolutions per minute, and of the engine 240 revolutions per minute.

The vacuum gage was placed in the goose neck of the pump, and the tap was 14.85 feet below the center of the horizontal discharge

The vacuum gage read 25.25 inches, which, when corrected for tude, is equivalent to 23.25 inches of mercury, or 25.6 feet of er. The total lift of the pump was, therefore, 40.45 feet.

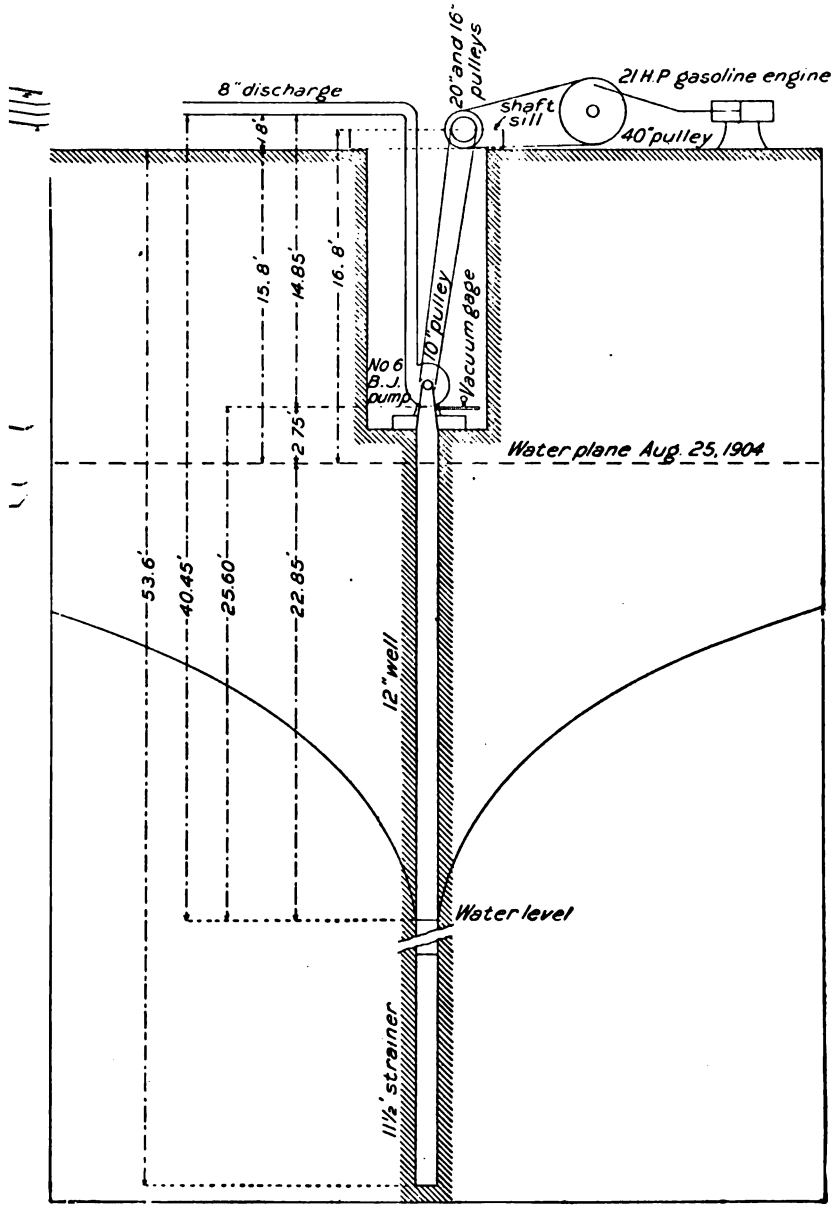


FIG. 20.—Diagram of pumping plant of Frank Burke, near Mesilla Park, N. Mex.

The discharge of the pump was determined by integrating with a Price acoustic-current meter in a rectangular flume through which the

s Cruces, who reports that 48 gallons of gasoline were consumed
ring that time. With gasoline at 17 cents a gallon the fuel cost of

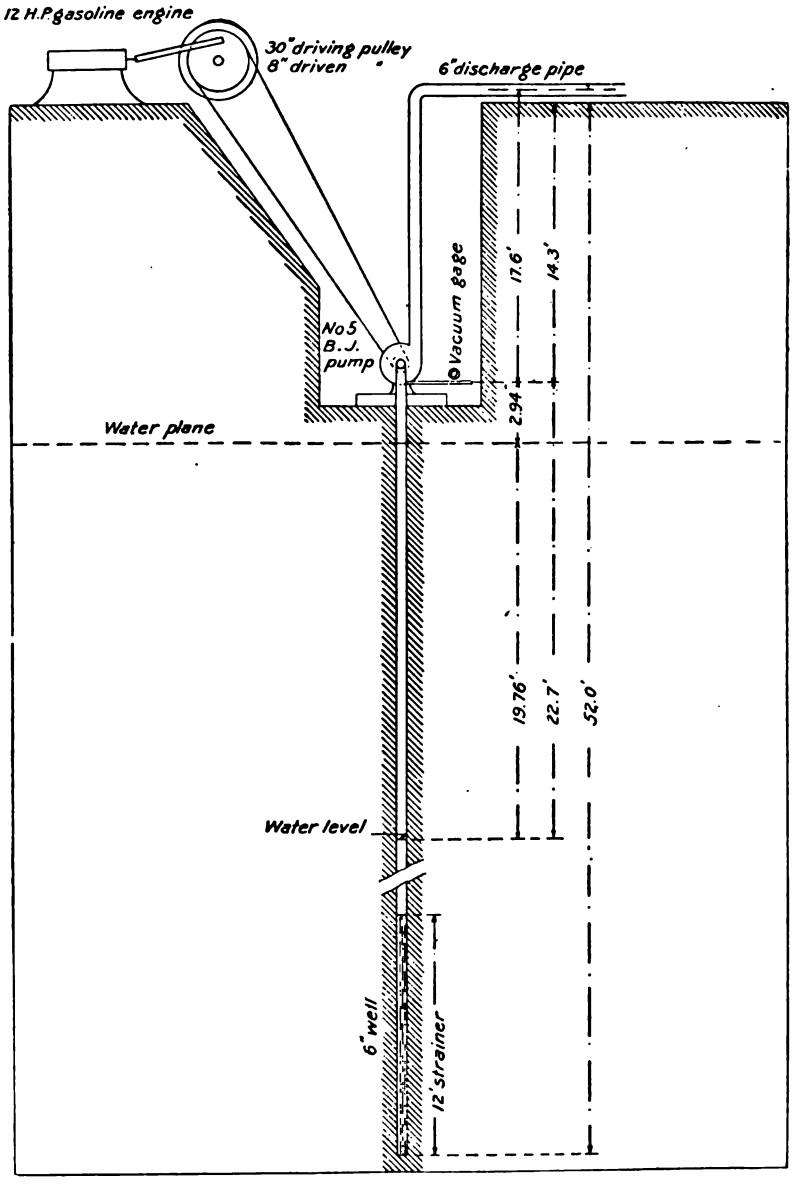


FIG. 21.—Diagram of pumping plant of Mrs. E. M. Boyer, near Las Cruces, N. Mex.

water would be 16.3 cents an hour, 0.412 cents per 1,000 gallons, $1.34 per acre-foot, and $0.000102, or one ninety-eighth of a cent per 1,000 foot-gallons.

PLANT OF W. N. HAGER.

This pumping plant is located on the ranch of W. N. Hage one-half mile west of the railroad station at Mesilla Park, N

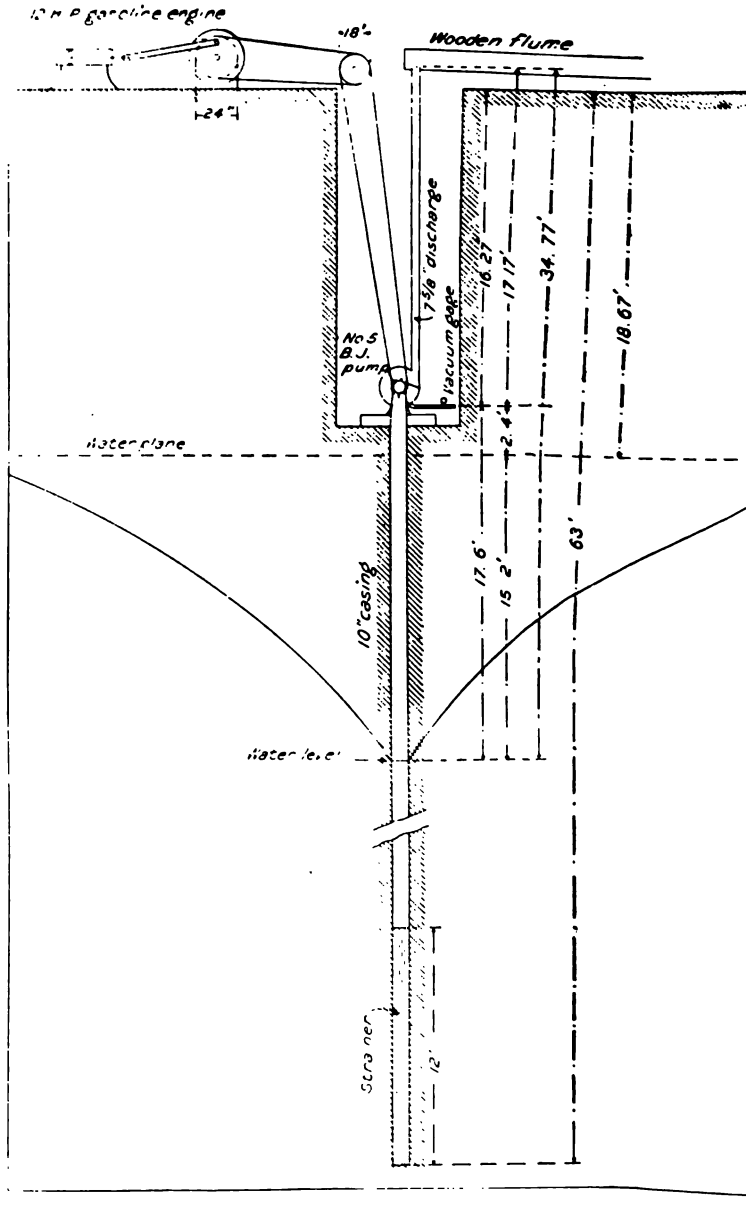


FIG. 22.—Diagram of pumping plant of W. N. Hager, near Mesilla Park, N. Mex.

Water is obtained from a 10-inch well, 63 feet deep, conta 12-foot, slotted, galvanized-iron Porcher strainer, 9¾ inches i

r. The pumping is done by a No. 5 Byron Jackson horizontal-
ıft, centrifugal pump, directly connected to the 10-inch well casing.
e pump is driven by a 12-horsepower Weber gasoline engine, power
ing transmitted by a belt from 24-inch driving pulley to 18-inch
lleys on countershaft, thence to 8-inch driven pulley on pump shaft.
At the time of the test the engine made 243 revolutions and 76
plosions per minute. The speed of the pump was 668 revolutions a
inute. The pump discharges through a 7¾-inch vertical discharge
pe into a rectangular wooden flume. The discharge was measured
y integrating in this flume with a Price acoustic current meter. The
idth of flume was 1.63 feet. At the selected cross section the water
ad an average depth of 0.308 feet and an average velocity of 1.171
eet per second. The total discharge was therefore 0.590 second-feet,
r 325 gallons a minute. An attempt was made to catch the water in
a tub holding 15.9 gallons. The time required to fill the tub was
letermined by a stop watch, but as the water had to be diverted into
he tub by closing a gate at the end of the rectangular flume, the
results are not satisfactory. The average time required to fill the tub
in seven trials was 4.3 seconds, indicating a discharge of only 209 gal-
lons a minute. This result is known to be valueless, but it illustrates
the impracticability of measuring such a discharge by means of a small
tub, unless the tub can be placed directly under the discharging stream
of water without the necessity of diverting the water to one side.

The vacuum-gage tap was 16.27 feet below the surface, and 16.84 feet below the top of the 7¾-inch discharge pipe. The water jet is 0.33 feet above the mouth of the discharge pipe. The vacuum gage read 17.5 inches, or 15.5 inches of mercury, when corrected for altitude. This is equivalent to 17.6 feet of water, making total lift of pump 34.77 feet. The vacuum-gage tap was 2.405 feet above the water plane, so that the water in well was lowered 15.2 feet during pumping. The specific capacity of the well is therefore 22.5 gallons per minute, or 0.76 gallons per minute for each square foot of well strainer.

The amount of gasoline used was determined by measurement in a round tank 1.87 feet in diameter. In one hour a depth of 0.09 feet of gasoline was consumed, or 1.84 gallons. With gasoline at 17 cents per gallon, the fuel cost of water was 31 cents per hour, 1.6 cents per 1,000 gallons, and $5.14 per acre-foot. The lift being 34.77 feet, the cost of fuel for 1,000 foot-gallons was $0.00046, or one twenty-second of a cent.

PLANT OF A. L. HINES.

This plant is located on the ranch of Dr. A. L. Hines, about 1 mile north of east from the old village of Mesilla. Water is obtained from a well 5¾ inches in diameter and 59 feet deep. The log of this well showed 8 feet of soil, 11 feet of dry sand, 28 feet of quicksand, and 12

feet of gravel on top of quicksand of unknown thickness. T
is recovered by a No. 4 Rumsey horizontal-shaft centrifugal
which is driven by an 8-horsepower vertical gasoline engine p

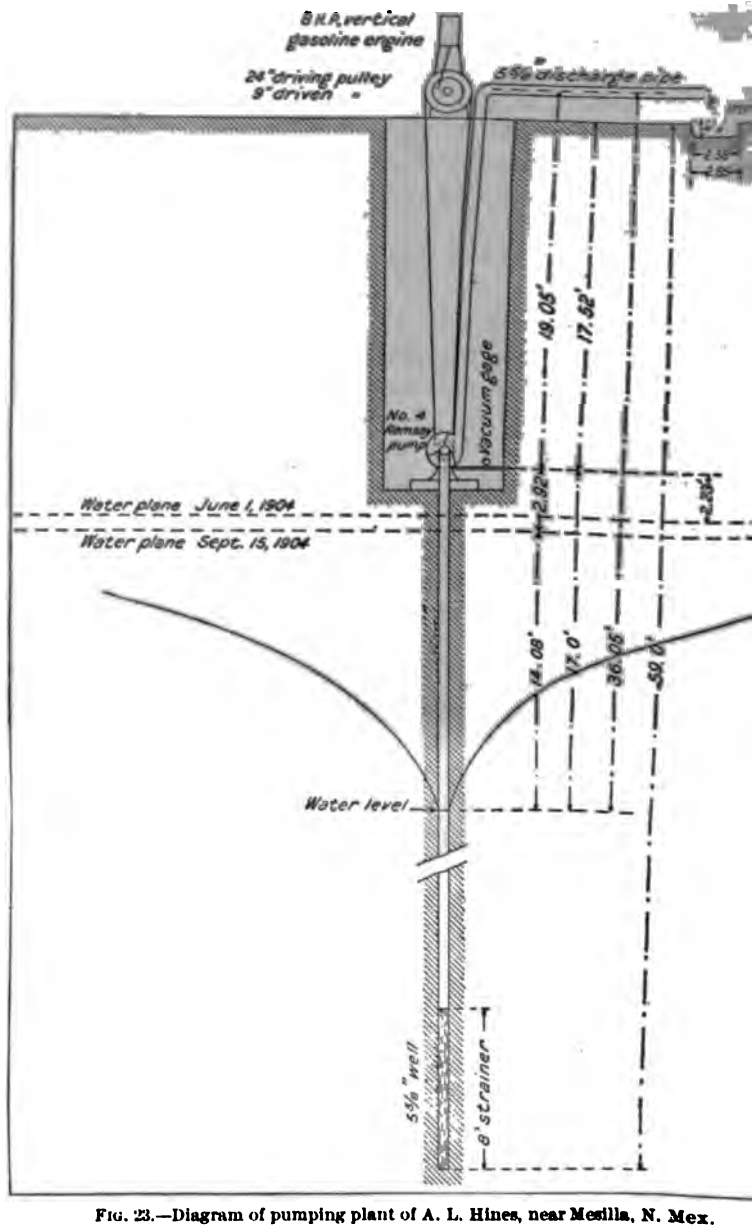


FIG. 23.—Diagram of pumping plant of A. L. Hines, near Mesilla, N. Mex.

sills extending across the top of the well pit. The engine was
factured by the Chicago Gas Engine Company. It is directly
to pump shaft from a 24-inch driving pulley and 9-inch driven

engine made 238 revolutions and 119 explosions per minute. speed of the pump was 594 revolutions per minute.

he water plane was 2.92 feet below the vacuum-gage tap in goose- of pump on September 15, 1904, and 2.23 feet below on June 1, 4; the water plane had fallen, therefore, in this interval about 8½ nes. The pumping plant had been in use only twenty days during summer. The vacuum-gage tap was 19.05 feet below the center the horizontal 5⅝-inch discharge pipe. The vacuum gage read 17 hes, which, corrected for altitude, is equivalent to 15 inches of mer- ry, or 17 feet of water. The total lift of the pump was, therefore, .05 feet.

The discharge was measured with great precision by determining ith a stop watch the time required to fill a wrought-iron rectangular nk. The water was conducted across the tank by means of an extra iece of iron pipe until the pumping plant had been in operation for ome time, when the extra pipe was suddenly pulled off. The tank eld 15.08 cubic feet and was filled in 30.6 seconds. The discharge vas, therefore, 0.492 second-foot, or 271 gallons per minute.

An excellent opportunity was offered for testing the accuracy of stimating the discharge from partly filled pipes by determining the mean velocity of the stream by a small current meter. Only 44.3 per cent of the cross section of the 5⅝-inch discharge pipe was filled by the water raised by the pump. The area of the cross section was 0.076 square foot, and the velocity of the water, as given by the current meter, was 8.47 feet per second. The discharge was, therefore, 0.642 second-foot, or 290 gallons per minute. The true discharge was 271 gallons per minute, showing an error of 5.3 per cent in the meter determination.

The water in the well was lowered 14.08 feet during pumping; therefore, the specific capacity of the well was 19.2 gallons per minute. As the area of the well strainer was 11.3 square feet, the specific capacity per square foot of well strainer was 1.79 gallons per minute.

At this plant 1.5 gallons of gasoline were used per hour. This is at least 50 per cent more than should have been used. With gasoline at 17 cents a gallon, the hourly cost of fuel was 25½ cents. As the yield was 16,250 gallons of water an hour, the fuel cost was $0.0157 per 1,000 gallons, $5.10 per acre-foot, and $0.000435, or one twenty-third of a cent per 1,000 foot-gallons.

PLANT OF THEODORE ROUALT.

This plant is on the ranch of Theodore Roualt, about 3 miles northwest of Las Cruces, N. Mex. Water is obtained from a 10-inch well 48 feet deep that contains 10 feet of 9¾-inch slotted galvanized-iron strainer. It is raised by a No. 3 Van Wie vertical-shaft centrifugal pump, driven by a 10-horsepower Nagle steam engine, on 18-horsepower

horizontal wood-burning boiler. The engine is directly belted to the pump shaft from a 30-inch driving pulley to a 12-inch driven pulley.

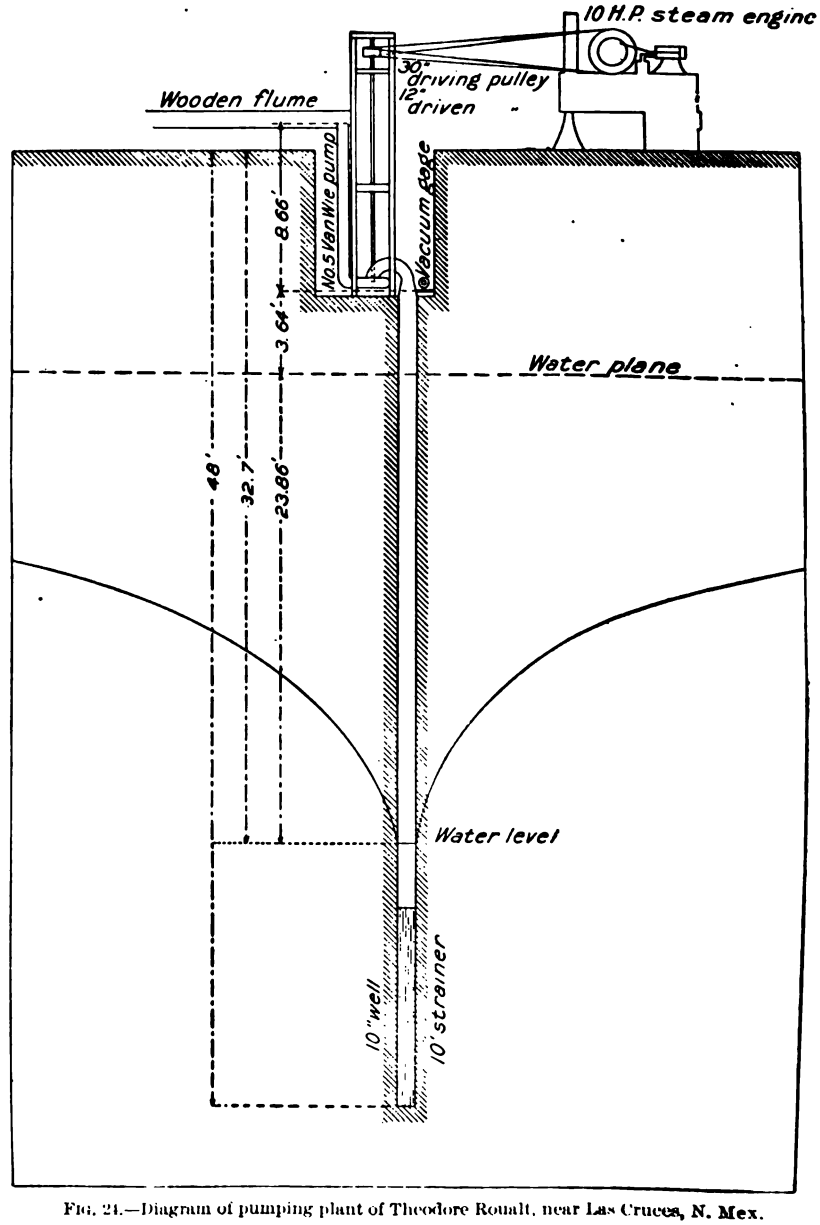
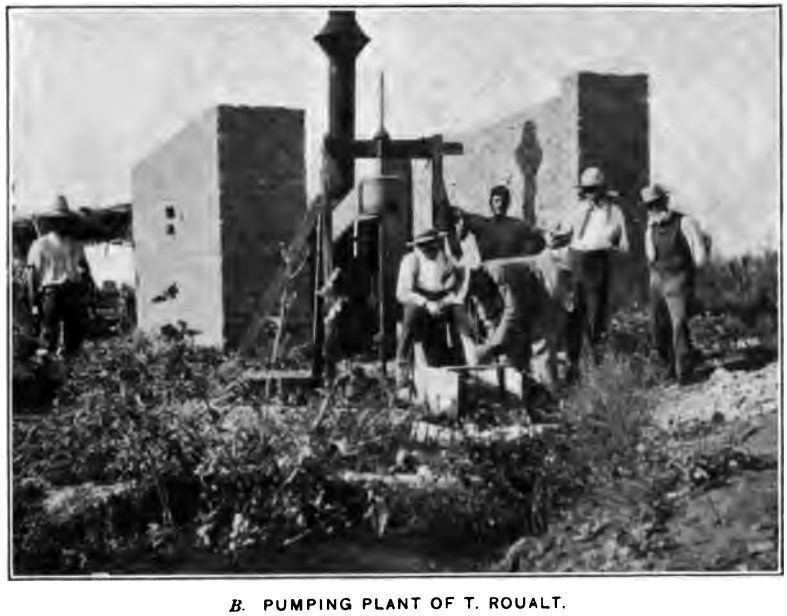


FIG. 24.—Diagram of pumping plant of Theodore Roualt, near Las Cruces, N. Mex.

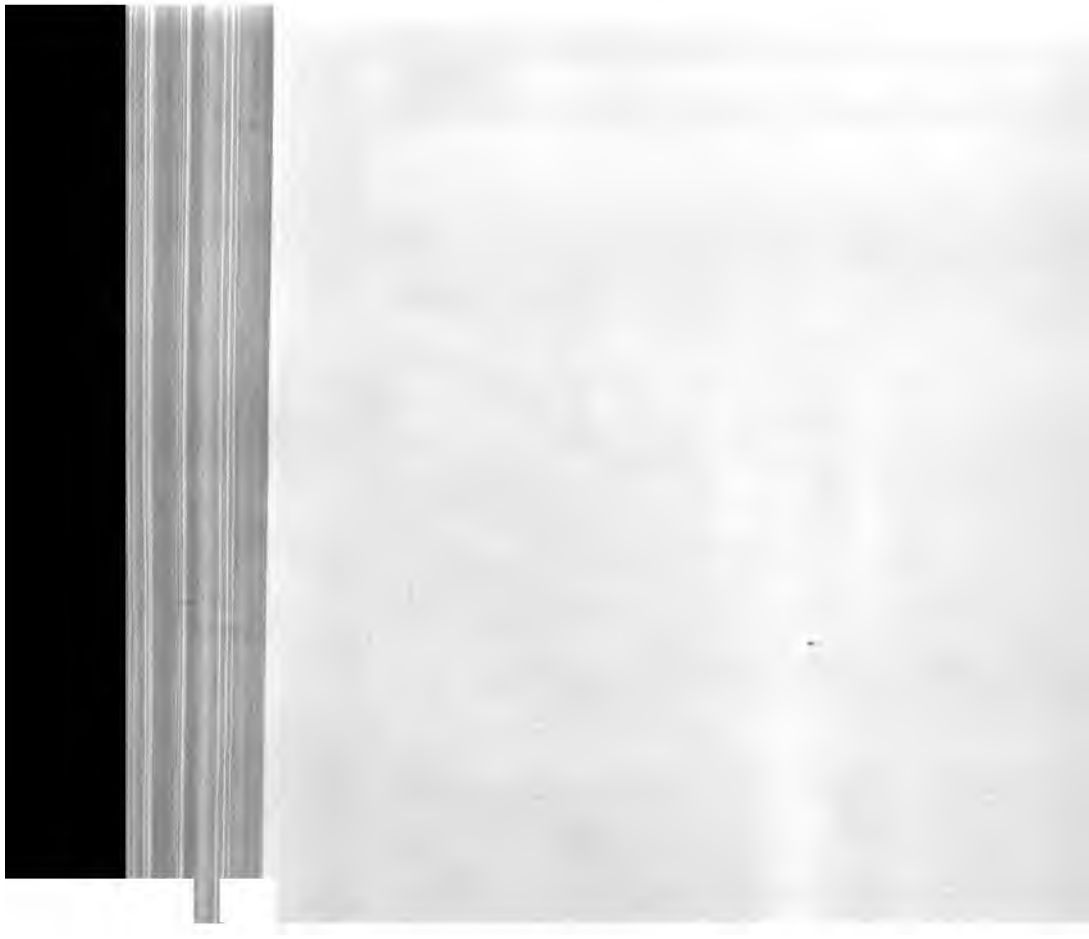
The water is discharged through an 8-inch vertical pipe into a rectangular flume.

The engine made 205 and the pump 525 revolutions per minute.

A. DISCHARGE FROM WELL NO. 1, HORACO RANCH COMPANY.



B. PUMPING PLANT OF T. ROUALT.



e steam pressure varied between 81 and 83 pounds. The vacuum-
ge tap was 3.64 feet above the water plane, 7.96 feet below the top
bottom plank of flume, and 8.66 feet below the top of water jet.
The vacuum gage read 24.25 inches, which is equivalent, when cor-
cted for altitude, to 22.25 inches of mercury, or 25.5 feet of water,
aking the total lift 34.16 feet. The discharge was measured by inte-
ating with a Price acoustic current meter in the rectangular flume.
he selected cross section had a width of 1.19 feet, an average depth
: 0.35 foot, and an area of 0.417 square foot. As the average velocity
as 1.867 feet per second, the discharge was 0.78 second-foot or 351
allons per minute. From this it is estimated that the specific capacity
f the well is 16 gallons per minute, or 0.627 gallon per minute for
ach square foot of strainer.

The cost of fuel used for pumping can be readily estimated from care-
ul tests by Mr. Roualt. For one irrigation of a 70-acre field of toma-
oes the pump was run twenty-eight days of twenty-four hours, and
75 cords of cottonwood, costing $2 per cord, were consumed. During
the twenty-eight days of twenty-four working hours each 14,150,000
gallons, or 43.5 acre-feet, of water were pumped. The total cost of
wood being $120, the fuel cost of water was 1.06 cents per 1,000 gal-
lons, $3.45 per acre-foot, and $0.00031, or about one thirty-second of
a cent, per 1,000 foot-gallons.

PLANT OF G. H. TOTTEN.

This plant is located on the ranch of G. H. Totten, about one-half of a mile west of the old village of Mesilla, N. Mex. Water is obtained from a 10-inch well, 62 feet deep, that contains 11½ feet of 9-inch slotted galvanized-iron strainer. It is raised by a No. 6 Byron Jackson horizontal-shaft centrifugal pump, driven by a 28-horsepower Ohio gasoline engine. The engine is belted from a 36-inch driving pulley to a 16-inch pulley on countershaft; thence from a 15-inch pulley on countershaft to a 10-inch pulley on pump. The engine made 205 revolutions and an average of 78 explosions per minute. The speed of the pump was 692 revolutions a minute.

The water is delivered through an 8-inch vertical discharge pipe into a horizontal rectangular wooden flume. The vacuum-gage tap on pump was 3.9 feet above the water plane, 16.83 feet below top of discharge pipe, and 16.95 feet below top of water jet. The vacuum gage read 25.25 inches, which is equivalent, after correction for altitude, to 23.25 inches of mercury, or 26.4 feet of water. The total lift is, therefore, 43.35 feet.

The discharge was measured by integrating with a Price acoustic current meter in rectangular flume. The selected cross section had a width of 1.83 feet, an average depth of 0.38 foot, and an effective area

of 0.695 square foot. The mean velocity of the water was 1.482 feet per second, giving a total discharge of 1.03 second-feet, or 464 gallons per minute.

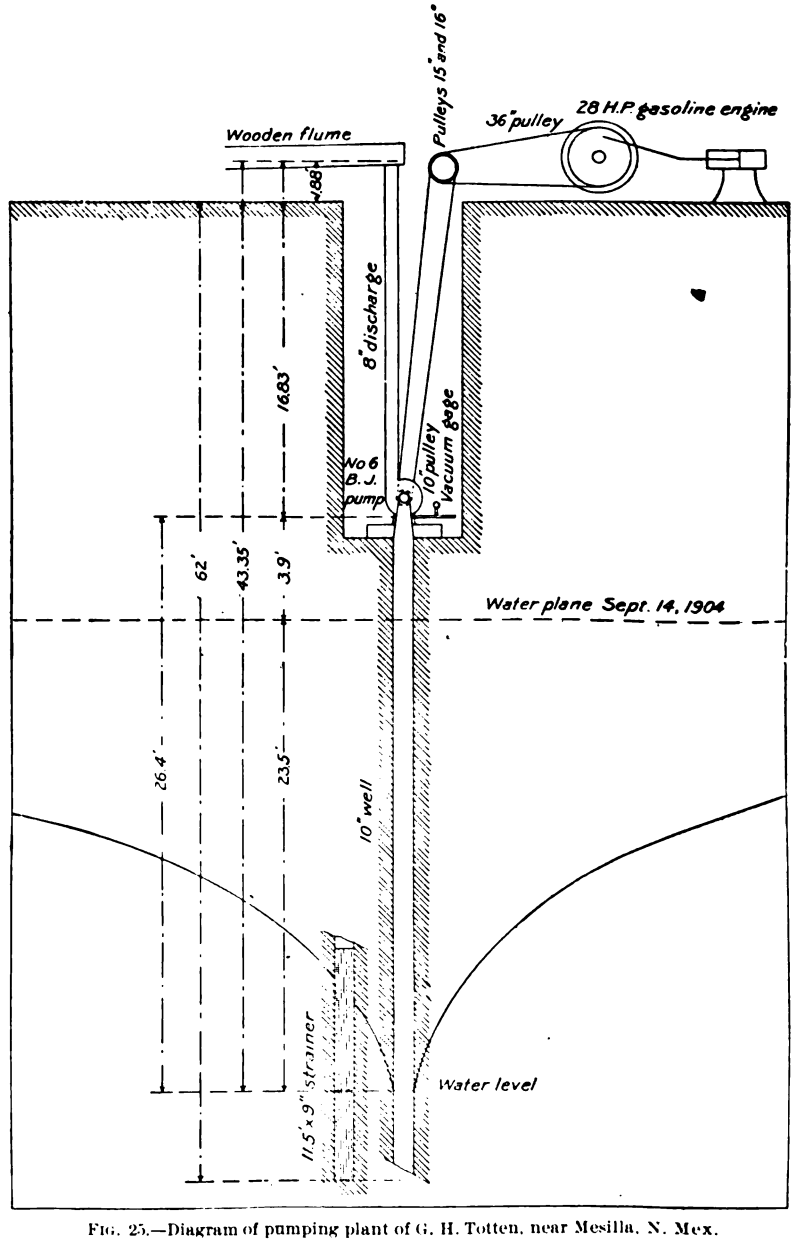


FIG. 25.—Diagram of pumping plant of G. H. Totten, near Mesilla, N. Mex.

The water in the well was lowered 22.5 feet during pumping, from which the specific capacity of the well is estimated to be 20.6 gallons a minute, or 0.76 gallon per minute for each square foot of strainer.

The discharge was also determined from the dimensions of the parabola of flow as the water left the flume. The end of the flume was almost exactly level and the water fell freely for a sufficient distance to permit the determination of the dimensions of the parabola of the sheet. This is shown in fig. 26. The water had an average depth of 0.171 foot at the end of flume, and in a total fall of 2.05 feet moved forward 1.285 feet. According to the laws of falling bodies, a body falls 2.05 feet in 0.356 second. If the water advances 1.285 feet in 0.356 second, its mean velocity per second would be 1.285 divided by 0.356, or 3.6 feet. The area of the stream is 0.171 by 1.83, or 0.313 square foot. This gives a total discharge of 1.13 second-feet, or 507 gallons per minute. These results are undoubtedly slightly too large.

The pumping plant had been used but a short time, and no experimental run had been made to determine the quantity of gasoline required. As the gasoline tank was situated so that without a consid-

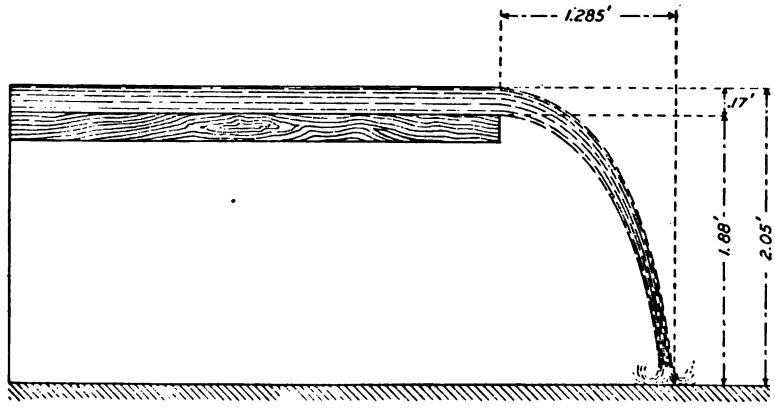


FIG. 26.—Parabola of discharge from flume at Totten's well.

erable expenditure of time it was impracticable to ascertain the amount of gasoline used, no determination was made during the test. However, it was estimated that the 28-horsepower engine gave 22 effective horsepower. It may therefore be safely assumed that about 2.2 gallons of gasoline were used per hour. If this amount were used, and gasoline costs 17 cents per gallon, the fuel cost of water would be 37 cents an hour, $0.0133 per 1,000 gallons, $4.34 per acre-foot, and $0.000307, or about one thirty-third of a cent per 1,000 foot-gallons.

PLANT AT AGRICULTURAL COLLEGE.

This plant consists of a 12-inch and a 6-inch well located on the experimental farm of the New Mexico Agricultural College. A complete test of this plant was not made, as the work with these wells is frequently reported upon by members of the faculty of the Agricul-

tural College. Only sufficient tests were made to determine the specific capacity of the large well in order to make comparisons possible with the other pumping plants in the valley. At the time of the test a

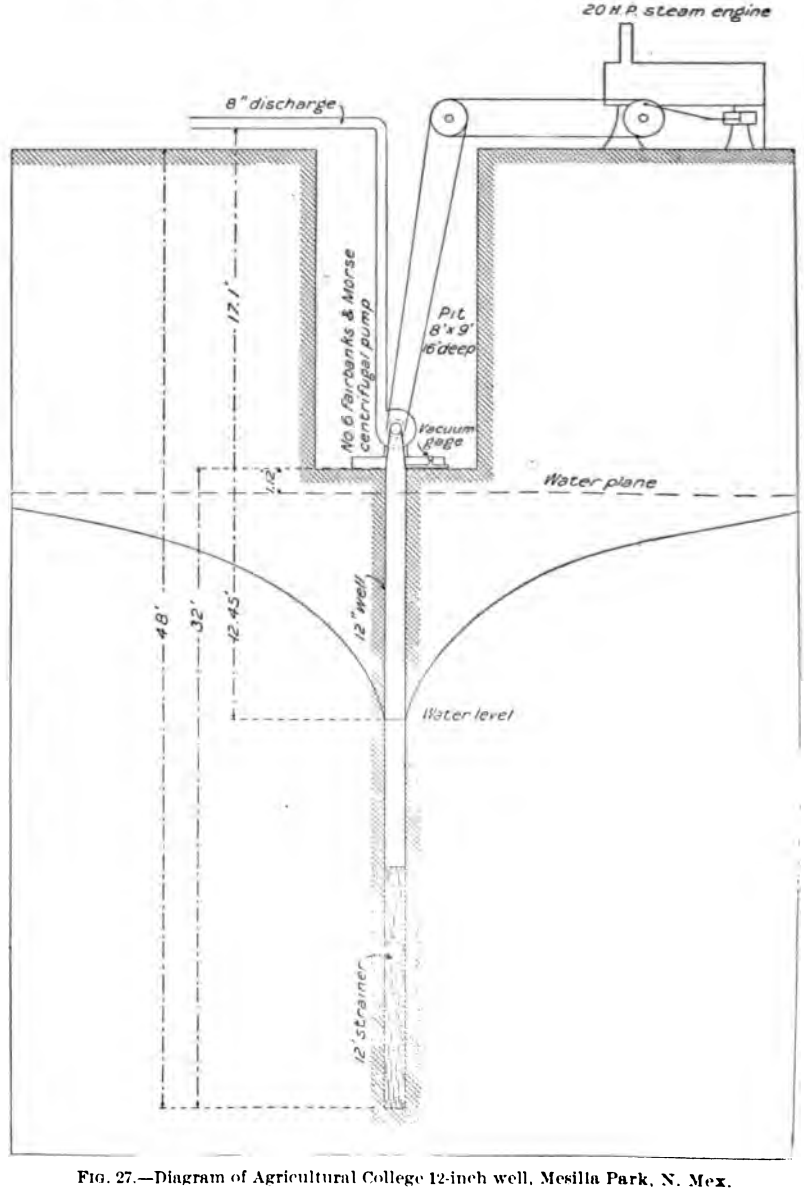


FIG. 27.—Diagram of Agricultural College 12-inch well, Mesilla Park, N. Mex.

No. 6 Fairbanks-Morse centrifugal pump was in use, but the pumps are frequently changed for experimental purposes. The pump is speeded so as to discharge 1,000 gallons a minute at the measuring

, in order that a known amount of water may be provided for the erimental plats of ground.

t the time of the test there was in use a 30-horsepower steam ine, which has ample power to drive pumps placed on both wells. ien both wells are used, about 1,800 gallons per minute can be ained.

)n August 25, 1904, the vacuum gage read 13 inches, which, cor- ted for altitude, is equivalent to 11 inches of mercury, or 12.45 t of water. The lift above the vacuum-gage tap was 17.10 feet, king the total lift 29.55 feet. The water level in the well was wered 11.37 feet by pumping, from which the specific capacity of e well is computed to be 88 gallons per minute. As the well strainer 12 inches in diameter, 12 feet long, and 27.6 square feet in area, the ecific capacity per square foot of strainer is 2.32 gallons per minute. The cost of fuel per acre-foot, as given in the table on p. 35, is ken from the bulletin issued by Professors Vernon and Lester in 903. These results were obtained with a 20-horsepower steam engine ormerly used. These results are included in the table for the pur- ose of comparison with the results at other plants.

TESTS OF PUMPING PLANTS NEAR BERINO, N. MEX.

PLANTS OF HORACO RANCH COMPANY.

The Horaco Ranch Company has three plants in an east-west line on a ranch just west of Berino, N. Mex. The east well is No. 3, the middle well is No. 1, and the west well is No. 2.

Well No. 3 is 62 feet deep. It is cased with 9⅝-inch pipe and contains 18 feet of strainer made of 9⅝-inch casing drilled with forty 1½-

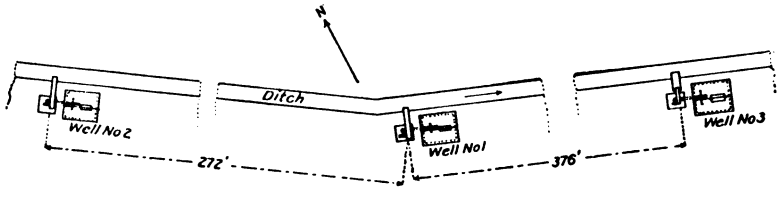


FIG. 28.—Plan of pumping plants of the Horaco Ranch Company, Berino, N. Mex.

inch holes to every linear foot of strainer and wound with No. 9 galvanized-iron wire wrapped so as to leave horizontal slots one-eighth of an inch in width. This strainer is locally known as the "Mott" strainer.

Water is obtained by means of a No. 5 Byron Jackson horizontal-shaft centrifugal pump, driven by a 12-horsepower Weber gasoline engine. The water is discharged through a 7-inch pipe, which rises

at an angle of 45° from the pump in the well pit. The engine made 244 revolutions and 97 explosions per minute. The pump made 692 revolutions a minute, and was belted directly to the engine from a

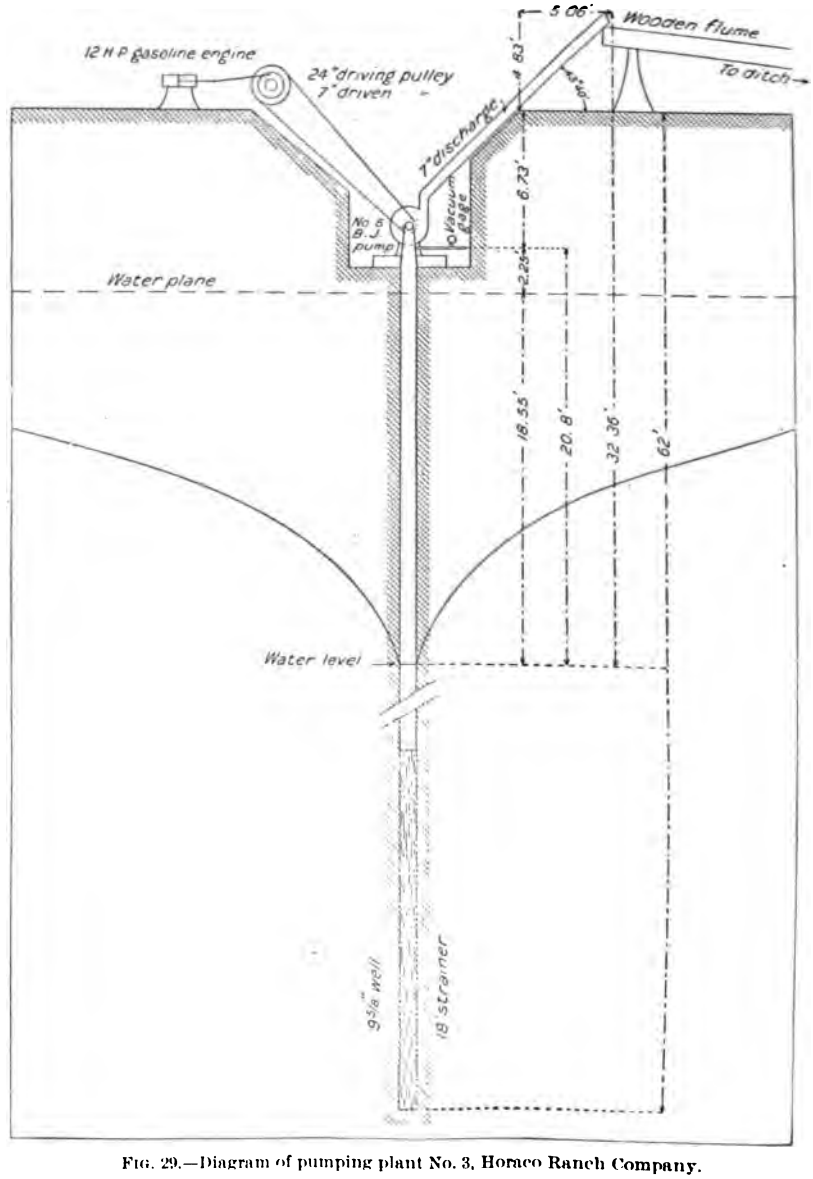


FIG. 29.—Diagram of pumping plant No. 3, Horace Ranch Company.

24-inch driving pulley to a 7-inch driven pulley. On September 11 1904, the water plane was 2.25 feet below the vacuum-gage tap which was 11.56 feet below the end of the discharge pipe. Th

um gage read, after one hour's pumping, 19.8, which, when cor-
ed for altitude, is equivalent to 17.8 inches of mercury, or 20.8
of water. The total lift of the pump was, therefore, 32.36 feet.
he discharge was measured by holding a small Price acoustic
rent meter in the mouth of the 7-inch discharge pipe. It was 1.71
ond-feet, or 750 gallons a minute.

As determined by Mr. E. L. Houck, principal owner of the Horaco
ich, a barrel of 50 gallons of gasoline was consumed by the engine
well No. 3 in fifty-three hours. With gasoline at 17 cents per
llon the fuel cost of water was 16 cents an hour, or $0.00356 per
00 gallons, or $1.16 per acre-foot. Since the total lift of the pump
31.76 feet, the cost of fuel for 1,000 foot-gallons is $0.000112, or
ie eighty-ninth of a cent. The consumption of gasoline at the time
the test was measured by noting the changing level of the gasoline
a cylindrical tank 1.85 feet in diameter. The change of level in
ne hour was 0.0867 foot. This is equivalent to 1.76 gallons an hour.
On this basis the fuel cost of water was $2.23 per acre-foot, and
0.000314, or one forty-seventh of a cent per 1,000 foot-gallons.

Well No. 1 of the Horaco Ranch Company is 376 feet west from well No. 3. It is 75 feet deep, is cased with 7⅝-inch pipe, and equipped with 18 feet of Mott strainer. Water is delivered through a 7⅝-inch vertical pipe opening into a horizontal wooden flume. It is raised by a No. 5 Byron Jackson horizontal-shaft centrifugal pump, driven by a 12-horsepower Weber gasoline engine. The engine made 238 revolutions and 106 explosions a minute. The pump made 815 revolutions a minute and was belted directly to the engine from a 24-inch driving pulley to a 7-inch driven pulley.

The vacuum-gage tap was 0.43 foot above the water plane on September 11, 1904. It was 7.1 feet below the surface and 8.95 feet below the end of vertical discharge pipe. As the water jet rose 0.762 foot above the end of the discharge, the total lift above the vacuum-gage tap was 9.71 feet. The vacuum gage read 14.5, which, corrected for altitude, is equivalent to 12.5 inches of mercury, or 14.18 feet of water. The total lift of the pump was, therefore, 23.89 feet.

The discharge was measured by integrating with a Price acoustic current meter in the rectangular flume. The selected cross section had an average depth of 0.278 foot, an average width of 1.42 feet, and an area of 0.395 square foot. The average velocity of the water was 4.707 feet per second, giving a discharge of 1.86 second-feet, or 837 gallons per minute.

The area of the well strainer is 36 square feet. The water level in the well was lowered 13.75 feet during pumping, and therefore the specific capacity of the well is 60.8 gallons per minute, or 1.69 gallons per minute for each square foot of strainer.

Although the amount of water obtained at well No. 1 is very much greater than at well No. 3, the cost for fuel is substantially the same. The consumption of gasoline is slightly less than 1.2 gallons an hour. With gasoline at 17 cents a gallon, the hourly cost is 20 cents. The

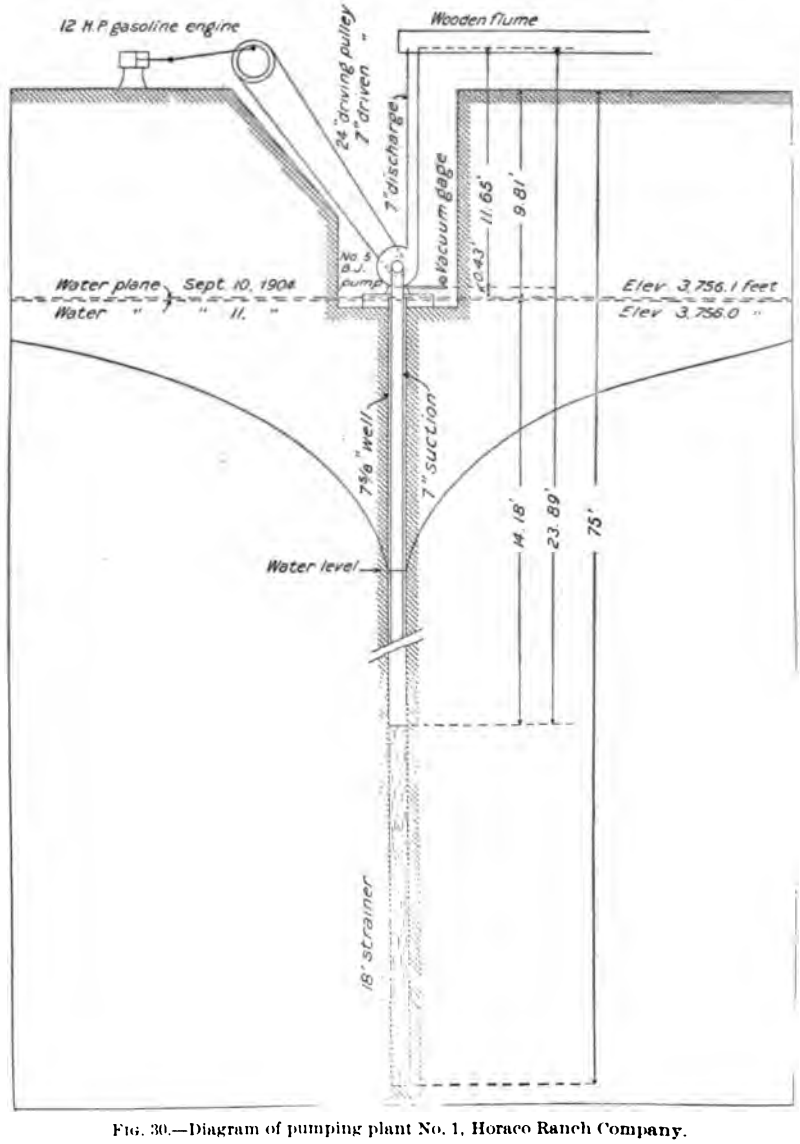


FIG. 30.—Diagram of pumping plant No. 1, Horaco Ranch Company.

amount of water obtained being 837 gallons a minute, or 50,220 gallons an hour, the fuel cost was $0.004 per 1,000 gallons, or $1.30 per acre-foot. The lift at well No. 1 being 23.89 feet, the cost of fuel for each 1,000 foot-gallons was $0.000167, or one-sixtieth of a cent.

Well No. 2 of the Horaco Ranch Company is 376 feet west of well 1. It is 53 feet deep, is cased with 9⅝-inch pipe, and is equipped with 18 feet of Mott strainer at the bottom. Water is raised by a No. 3 Byron Jackson horizontal-shaft centrifugal pump, driven by a

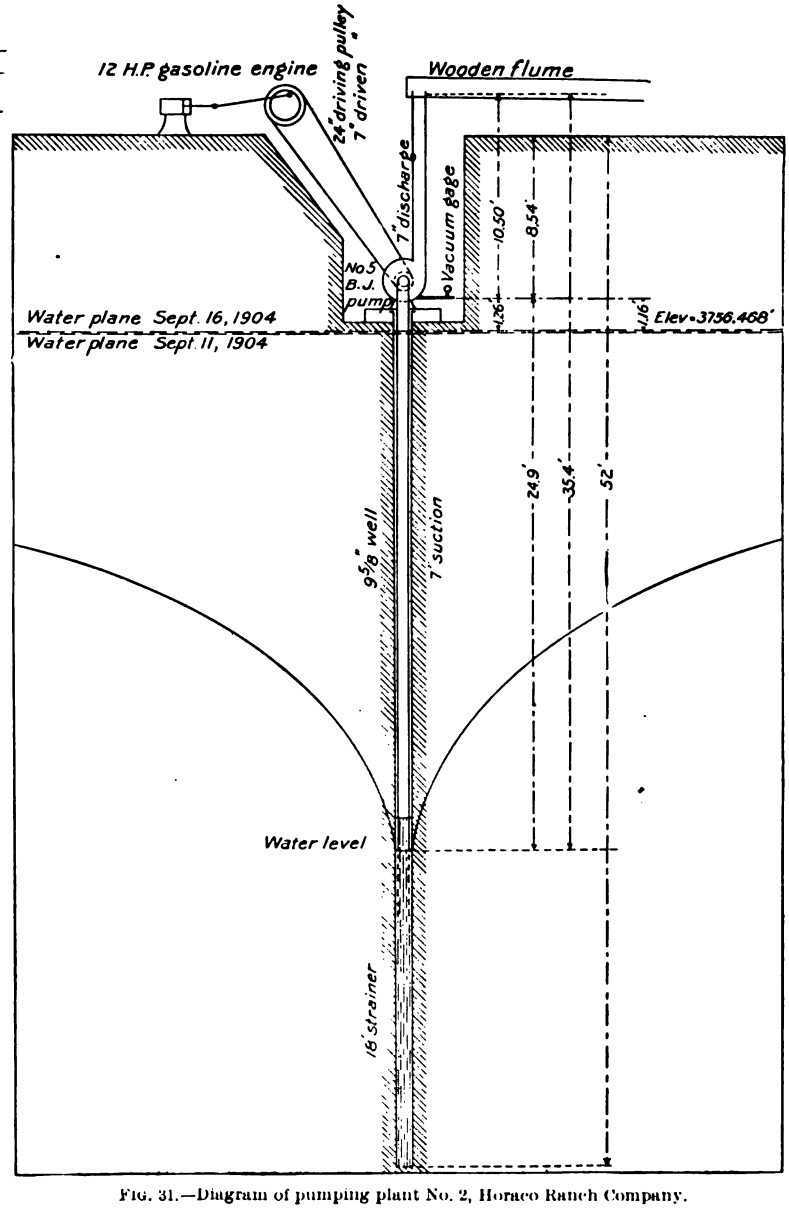


FIG. 31.—Diagram of pumping plant No. 2, Horaco Ranch Company.

12-horsepower Weber gasoline engine. It is taken from the well through a 7-inch suction and discharged through a 7-inch vertical pipe into a horizontal flume. The engine made 239 revolutions and

103 explosions a minute. It was belted directly to the pump shaft from a 24-inch driving pulley to a 7-inch driven pulley. The speed of the pump was 700 revolutions a minute.

The vacuum-gage tap placed in the goose neck of the pump was 1.26 feet above the water plane and 10.02 feet below the top of the vertical discharge pipe. As the water jet rose 0.34 foot above the discharge pipe, the total lift of the pump above the vacuum-gage tap was 10.36 feet. The vacuum gage read 24 inches, which, corrected for altitude, is equivalent to 22 inches of mercury, or 24.9 feet of water. The total lift of the pump was therefore 35.26 feet.

The discharge was measured by integrating with a Price acoustic current meter in the rectangular flume. The selected cross section had an average depth of 0.251 foot, a width of 1.44 feet, and an area of 0.362 square foot. The mean velocity was 1.172 feet per second, which gives a total discharge of 0.425 second-foot, or 191 gallons per minute.

The water in the well was lowered 23.64 feet by pumping. This makes the specific capacity of the well 8.1 gallons per minute, or 0.178 gallon per minute for each square foot of strainer.

The consumption of gasoline by the engine at well No. 2 is known by comparison with that at well No. 3. Although the amount of water pumped is very much less than at well No. 3, the consumption of gasoline is as great, and even slightly greater, say 1.2 gallons an hour. With gasoline at 17 cents per gallon the hourly cost of fuel is 20.4 cents. The fuel cost of water is then 1.78 cents per 1,000 gallons, $0.000505, or one-twentieth of a cent per 1,000 foot-gallons, and $5.80 per acre-foot.

Mr. Houck gives the combined cost of the three pumping plants on the Horaco ranch as follows:

Cost of pumping plants on Horaco ranch.

Three 12-horsepower Weber gasoline engines, three No. 5 Byron Jackson pumps with piping, belting, etc., all in place	$2,100.00
Wells at $2.50 per foot	475.00
Well pits, buildings, flumes, etc., extra	400.00
	2,975.00

Depreciation at 10 per cent and interest at 8 per cent amounts to $536 per annum. For an irrigation season of one hundred days this averages $5.36 per day, or $1.80 a day for each plant.

The hourly cost of plant No. 1 may be figured as follows:

Hourly cost of pumping plant No. 1 at Horaco ranch.

Fuel (gasoline)	$0.16
Interest and depreciation	.18
Labor, lubricating oil, etc	.10
Total	.44

The last item is based on the supposition that one man can run the three plants.

At well No. 1 the yield of water is 837 gallons a minute, or 50,220 gallons an hour. The cost is therefore $0.00876 per 1,000 gallons, or $2.85 per acre-foot.

The cost at the other plants is much greater on account of poorer wells. The wells would probably show little difference in capacity or cost of the water if they were all as deep as well No. 1. The coarse gravels were not reached at all in well No. 2, and were not penetrated in well No. 3.

Mr. Houck made a careful test of the amount of gasoline used at pumping plants Nos. 1 and 3 in November, 1904. Each of the engines at these plants ran sixteen hours on 16 gallons of gasoline. These tests are in substantial accord with the former tests quoted above, but show a slightly smaller quantity of gasoline consumed.

Plants Nos. 1 and 3 were used on two occasions to irrigate 25 acres of land, consisting of 21 acres of alfalfa and 4 acres of orchard and garden, and sixteen hours of continuous run were required at each trial. This is equivalent to about 2¼ inches of water per irrigation.

An interesting observation was made of the effect of stopping the pumps during the night instead of making a continuous run as above. When this was done the pumps had to be run two and one-half hours longer to irrigate land that had previously been irrigated in sixteen hours.

APPENDIX.

ANALYSES OF WELL WATER AND DATA CONCERNING WELLS AT AND NEAR EL PASO, TEX.

This information was furnished by Mr. A. Courchesne, of El Paso, Tex.

Water in corral at stone quarry above El Paso, Tex.

Analysis.	Parts per 100,000.	Probable combinations.	Parts per 100,000.
Silica	3.00	Silica	3.00
Alumina	2.00	Alumina	2.00
Lime	26.20	Carbonate of lime	34.00
Magnesia	6.11	Sulphate of lime	17.65
Soda	18.84	Sulphate of magnesia	18.30
Carbonic acid	15.00	Sulphate of soda	1.90
Sulphuric acid	23.70	Chloride of sodium	33.95
Chlorine (Cl)	20.60	Water of crystallization, etc.	1.20
Water of crystallization, or loss	1.20	Total solids	112.00
	116.65	Total hardness	62.20
Oxygen equivalent to Cl	4.65	Permanent hardness	28.20
Total solids	112.00		

This is not a good boiler water, though most of the solids will come down as sludge instead of sticking to tubes. Still there is enough in combination to make a hard seal of sulphate of lime and carbonate of magnesia. The water will corrode, but not badly.

Analysis of water from mile 211, El Paso and Southwestern Railroad.

Constituent.	Parts per 100,000.	Probable combination.	Parts per 100,000.
Silica	7.00	Silica	9.00
Alumina	1.00	Alumina	1.00
Lime	6.70	Carbonate of lime	12.00
Magnesia	2.80	Carbonate of magnesia	3.62
Soda	16.40	Sulphate of magnesia	3.45
Sulphuric acid	13.65	Sulphate of soda	20.33
Carbonic acid	7.48	Chloride of sodium	14.35
Chlorine (Cl)	8.70	Water of crystallization	.25
Water of crystallization	25	Total solids	62.00
	63.98		
Oxygen equivalent to Cl	1.98		
Total solids	62.00		

This is a good locomotive water, and is a fairly good drinking water, very slightly medical from Glaubers salts.

Water from 70-foot well at ranch of A. Courchesne, near Ysleta, Tex.

Constituent.	Parts per 100,000.
Silica	3.00
Alumina and phosphate	10.00
Carbonate of lime	15.00
Carbonate of magnesia	3.01
Carbonate of soda	12.13
Sulphate of soda	7.80
Chloride of sodium	23.30
Organic and water of crystallization	1.76
	106.00

This water is comparatively soft and good for boiler use. It has too much organic matter in it for a safe drinking water. The dried solids blacken on ignition and smell badly. It is probably polluted with sewage.

Water from lime quarry, El Paso, 30 feet deep.

Constituent.	Parts per 100,000.	Probable combinations.	Parts per 100,000.
Silica	2.60	Silica	2.60
Alumina	2.00	Alumina	2.00
Lime	44.72	Carbonate of lime	82.00
Magnesia	10.80	Sulphate of lime	65.30
Soda	65.80	Sulphate of magnesia	32.40
Sulphuric acid	60.00	Chloride of sodium	124.20
Carbonic acid	14.00	Water of crystallization	27.50
Carbonic	75.60	Total solids, 100 c	286.00
Water of crystallization	27.50	Total solids, grains per gallon (US)	167.00
	303.02		
Oxygen equivalent to Cl:	17.02		
Total solids, 100 c	286.00		

This water is not good for drinking or boiler purposes. It will scale and corrode badly. It could be made usable for boilers by treatment with caustic and carbonate of soda, but it would not then be a good water on account of high proportions of common salt.

Analyses of waters from wells of El Paso ice plant.

Constituent.	Surface water.	300-foot well (grains per U. S. gallon).	80-foot well (grains per U. S. gallon.)
Organic	5.4	3.033	5.249
Silica	2.8	.....	1.166
Sulphate of lime	.....	.....	35.003
Carbonate of lime	26.3	9.580	10.940
Carbonate of magnesia	5.3	1.102	.883
Chloride of sodium	36.9	6.102	52.464
Chloride of lime	.....	.....	4.391
Chloride of magnesia	.....	.....	9.802
Sulphate of magnesia	.....	.....	5.148
Sulphate of sodium	32.5	7.407	.....
Carbonate of sodium	5.2	.....	.....
Iron and alumina	.6	.....	.....
Total solids	115.0	27.224	125.046
Incrustants	34.9	10.682	47.992
Corroding salts	.....	.....	19.341
Rating for boiler purposes	Bad.	Good.	Very bad.

Analysis from water from new 400-foot well of El Paso Ice and Refrigerator Company, El Paso, Tex.

Constituent.	Parts per 100,000.	Probable combinations.	Parts per 100,000.
Silica	0.50	Silica	0.50
Alumina	Tr.	Alumina	Tr.
Lime	2.23	Carbonate of lime	4.00
Magnesia	3.00	Carbonate of magnesia	6.30
Soda	8.98	Carbonate of soda	1.59
Chlorine	5.31	Sulphate of soda	7.90
Carbonic acid	5.72	Chloride of sodium	8.71
Sulphuric acid	4.45	Total solids	29.00
	30.19	Total hardness	11.5
Oxygen equivalent to Cl	1.19		
Total solids	29.00		

This is a good water. The hardness is rather high, but it is temporary, and only a small part (about 20 per cent) will incrust, the rest falling as slugs in the boiler, which can be blown out.

Analysis of El Paso well water.

Constituent.	Grains per U. S. gallon.
Incrusting solids:	
Calcium carbonate	3.20
Calcium sulphate	None.
Calcium chloride	None.
Magnesium carbonate	1.39
Magnesium sulphate	None.
Magnesium chloride	None.
Iron and alumina	.07
Silica	1.61
Suspended matter	Trace.
Total	6.27
Nonincrusting solids:	
Sodium sulphate	5.82
Sodium chloride	7.02
Sodium carbonate	4.19
Total	17.03
Alkalinity	9.33
Hardness	5.26
Carbonic acid	2.42
Pounds of incrusting solids per thousand gallons	.90

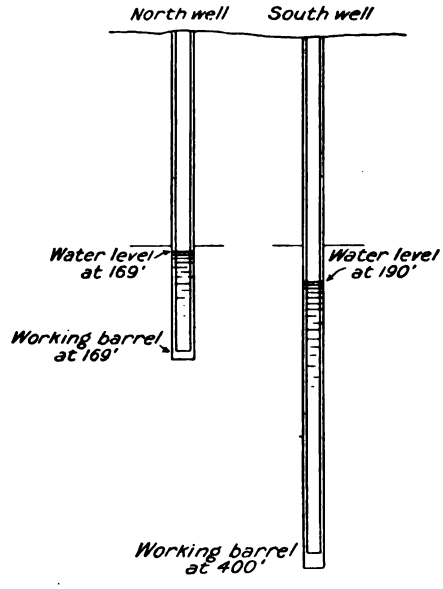


FIG. 32.—Wells at Fort Bliss station, El Paso and Northeastern Railroad.

Data concerning wells at Fort Bliss

NORTH WELL.

Completed: July 22, 1901.
Total depth: 249 feet.
Casing: 249 feet of 6-inch.
Depth of working barrel: 245 feet.
Water level: 169 feet below earth's surface.
Pump: 12 by 36 inches, Cook.
Tested capacity of well: 80,000 gallons per twenty-four hours.

SOUTH WELL.

Completed: 1901.
Total depth: 410 feet.
Casing: 410 feet of 6-inch.
Depth of working barrel: 400 feet.
Water level: 190 feet below earth's surface.
Pump: 10 by 36 inches, Cook.
Tested capacity of well: 30,000 gallons per twenty-four hours.

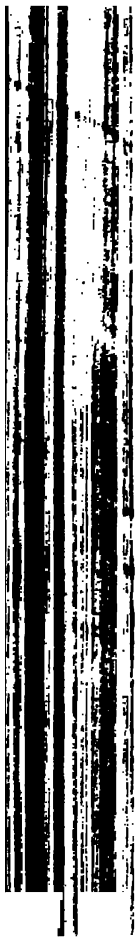
FEATURES COMMON TO NORTH AND SOUTH WELLS.

Contractor: William McLease.
Size of hole: 8 inches.
Pump column: 6-inch standard.
Working barrel: 5½-inch, Cook.
Well rods: No. 3; 3-inch hickory, 1½-inch straight pins.
Storage: 50,000 gallons, wooden tank.
Boiler: 30 horsepower, Economic.

Analysis of Fort Bliss well water.

Constituent.	Grains per U. S. gallon.
Calcium carbonate (incrusting)	4.90
Magnesium carbonate (incrusting)	3.09
Silica (incrusting)	1.34
Oxides, alumina and iron (incrusting)	.06
Alkali carbonates (nonincrusting)	2.74
Alkali sulphates (nonincrusting)	2.62
Alkali chlorides (nonincrusting)	1.63
Alkali nitrates (nonincrusting)	.70
Sulphates, lime, and magnesium	Traces.
Total incrusting solids	9.39
Total nonincrusting solids	7.69
Pounds incrusting matter per 1,000 gallons	1.34
Pounds nonincrusting matter per 1,000 gallons	1.09

This water should be classed as good.



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